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HAZARDOUS MATERIALS ACCIDENT REPORT

DERAILMENT OF A CSX TRANSPORTATION FREIGHT TRAIN AND FIRE INVOLVING BUTANE AKRON, OHIO FEBRUARY 26, 1989

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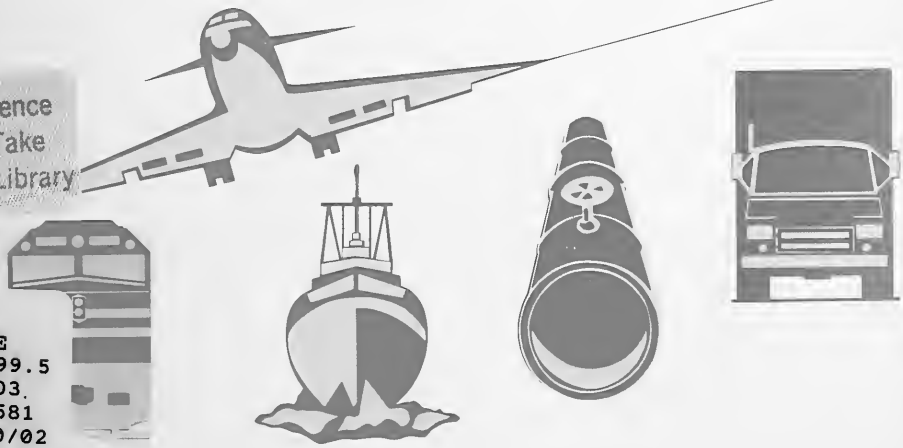

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16. Abstract

This report addresses the derailment of a freight train in Akron, Ohio, on February 26, 1989, and subsequent fire involving butane carried by the train. The safety issues discussed in the report are (a) the proximity of hazardous materials storage and plant facilities to mainline railroad tracks; (b) the lack of Federal requirements to maintain on board a train documents that identify the position and contents of cars carrying hazardous materials; (c) needs of emergency response personnel for technical assistance to evaluate dangers and risks during wreckage-clearing operations involving hazardous materials; (d) repair and inspection procedures at a rail car repair facility; (e) oversight of freight car repair facilities; (f) inspections of freight cars; and (g) maintenance and inspections of track. Safety recommendations were issued to CSX Transportation, Inc.; city of Akron, Ohio; Association of American Railroads; Federal Railroad Administration; National League of Cities; National Association of Counties; National Fire Protection Association; American National Standards Institute, Inc.; National Association of Regulatory Utility Commissioners; and the International Association of Fire Chiefs.

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EXECUTIVE SUMMARY

On February 26, 1989, CSX Transportation, Inc., freight train No. D812-26 derailed at mile post 16.1 while traveling about 43 mph over Consolidated Rail Corporation (Conrail) main track No. 1, near the south end of Conrail's rail yard, Akron, Ohio. Twenty-one freight cars in the train derailed, including nine tank cars filled with butane. The nine tank cars came to rest adjacent to a B.F. Goodrich Chemical Company plant, and butane released from two breached tank cars immediately caught fire. About 1,750 residents were evacuated from a 1-square-mile area. On February 28, 1989, while some of the derailed tank cars were being moved from the accident site, one tank car full of butane rolled off its trucks; as a result, about 25 families were evacuated from a second area.

The National Transportation Safety Board determined that the probable cause of the derailment of train D812-26 in Akron, Ohio, on February 26, 1989 was the inadequate rebuild and quality control procedures of the Northern Rail Car Corporation car repair facility and the inadequate inspections of car WSOR 501003 by designated car inspectors that permitted the car to enter and continue in service with excessive gib clearance and out-of-limits side bearing clearance. Contributing to the accident was the marginal condition of the track as a result of Conrail's decision to delay rehabilitation of the track or not to place a slow order on the track.

The following safety issues are discussed in this report:

1. The proximity of hazardous materials storage and plant facilities to mainline railroad tracks;

2. The lack of Federal requirements to maintain onboard a train a current consist to identify the position and contents of cars carrying hazardous materials;

3. Local emergency response personnel needs for technical assistance to evaluate dangers and risks during wreckage clearing operations involving hazardous materials;

4. Repair and inspection procedures at the rail car repair facility;

5. Oversight of freight car repair facilities;

6. Inspections of freight cars by designated car inspectors (carmen); and

7. Maintenance and inspections of track.

Recommendations concerning these issues were made to the CSX Transportation, Inc., the city of Akron, the Association of American Railroads, the Federal Railroad Administration, the International Association of Fire Chiefs, the National League of Cities, the National Association of Counties, the National Fire Protection Association, the American National Standards Institute, Inc., and the National Association of Regulatory Utility Commissioners.

DERAILMENT OF A CSX TRANSPORTATION FREIGHT TRAIN AND FIRE INVOLVING BUTANE IN AKRON, OHIO, FEBRUARY 26, 1989

INVESTIGATION

Events Preceding the Accident

On Sunday, February 26, 1989, about 4:00 p.m., the crewmembers for CSX Transportation, Inc. (CSX), freight train No. D812-26 reported for duty at the CSX train yard at Willard, Ohio. The traincrew consisted of an engineer and brakeman in the front locomotive and a conductor and flagman in the caboose at the end of the train. All four train crewmembers were regularly assigned to this run; according to the CSX, the conductor was in charge. Train D812-26 was destined for the CSX Akron Junction train yard in Akron, Ohio, about 76 miles away (figure 1). The trip was a regularly scheduled run, operating round trip between Willard and Akron, Sunday through Friday. On this day, the train was scheduled to make two stops to set off cars or to pick up cars en route to Akron Junction.

Before leaving Willard, the flagman picked up the train papers for the trip. Those papers included operating orders, a profile document,[1] and waybills. He gave a copy of those documents to the conductor and a copy of the profile and operating orders to the crewmembers in the front locomotive.

Federal regulations require that a traincrew be provided a document that identifies the position in the train of each car carrying hazardous materials.[2] For this trip, the profile listed all freight cars in the train when it left Willard, and the document identified the location of cars in the train that were carrying hazardous materials. The document did not identify the correct position of three cars in the train that did not carry hazardous materials; 49 CFR 174.26(b) did not require that those cars be listed on the document in their exact order. The document also did not list the caboose at the end. There was also no requirement that the document be kept current after the train left Willard; Part 174.26(b) specifically relieves a carrier from the responsibility of amending the document to reflect the position of cars carrying hazardous materials in the train when the makeup of the train

---

[1] The train profile document included a tonnage graph (showing the train's weight distribution) and list of cars in the train; special instructions that identified the proper shipping name and class of hazardous materials carried in the tank cars; a train switch list that listed the cars and identified locations where the cars were scheduled to be set off from the train; and emergency handling precautions for hazardous materials carried in the train.

[2] Title 49 CFR Part 174.26(b) states that "a train crew must have a document indicating the position in the train of each loaded placarded car containing hazardous materials, except when the position is changed or the placarded car is placed in the train by a member of the crew."

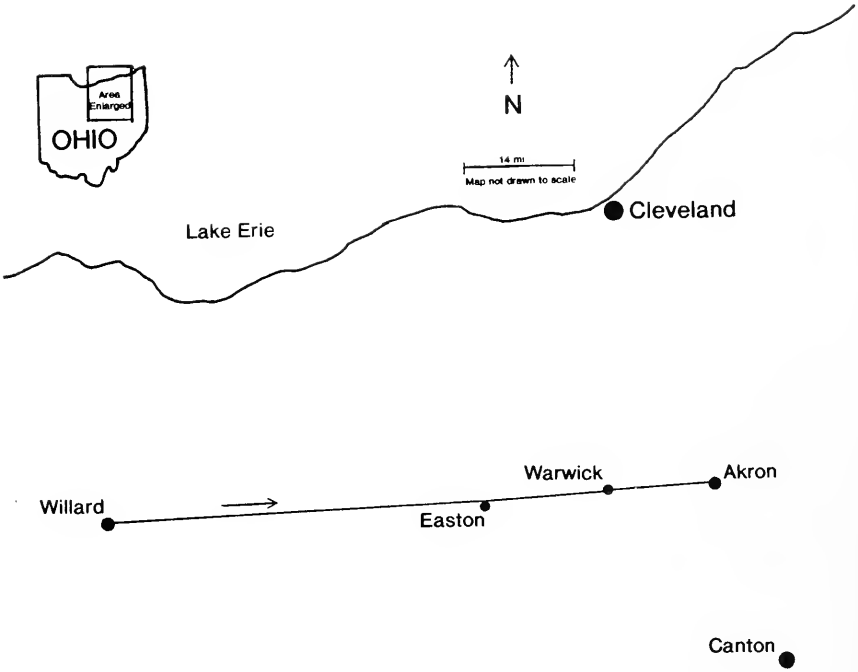

Figure 1.--The scheduled route for train D812-26.

is changed, or when cars carrying hazardous materials are added to the train after leaving the initial yard.

According to the conductor, following his normal procedure, he observed the cars in the train as it departed the Willard yard and before he boarded the caboose. He later said that he checked the cars to determine (1) if the cars were grouped in the proper order for set-off during the trip, and (2) if cars containing hazardous materials were proper distances from the engine and caboose;[3] he did not take exception to the order of cars. He did not attempt to determine if all cars in the train were in the same order as listed on the profile.

The profile document that was carried by the traincrew was generated from information entered into the CSX computer system. As the train departed the Willard yard, an employee in the yard tower observed the train and noticed that three cars in the train were in different positions than displayed on the computer list. He therefore changed the positions of the three cars on the computer; however, the new positions on the computer were not the same as the cars' positions in the train.[4] (When the derailment occurred later that evening, information retrieved by responding personnel about the makeup of the train reflected the order of cars as changed by the employee in the tower. An accurate list of the order of cars in the train when it left Willard was determined only after reviewing the location of cars at the accident scene.)

When the train departed Willard at 5:10 p.m., it consisted of 4 locomotives, 59 freight cars, and 1 caboose. Of the 59 freight cars, 22 contained hazardous materials: 5 tank cars of chlorine, 1 tank car of potassium hydroxide, 15 tank cars of butane, and 1 tank car of butadiene.

About 6:10 p.m., the train arrived in Easton, Ohio, the first scheduled stop. At Easton, three cars of lumber were set off by the brakeman; no cars were picked up at this location. The train then contained 56 freight cars. None of the crewmembers made notations on the profile document to identify the three cars set off from the train at Easton. Instead, the conductor followed company procedures and prepared a separate company document called a "wheel report" to identify those cars that were set off.[5]

About 6:37 p.m., the train arrived in Warwick, Ohio, the second scheduled stop. At Warwick, the brakeman set off 11 cars, including the 5 tank cars of chlorine and the 1 tank car of potassium hydroxide. Also at Warwick, the brakeman added a caboose and four freight cars to the train; none of the cars picked up in Warwick contained hazardous materials. The

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[3] Title 49 CFR Parts 174.85 through 174.93 contain safety requirements that address the placement of cars carrying hazardous materials in trains.

[4] This action did not change the order of hazardous materials tank cars on the list.

[5] The wheel report is not a document required by Federal regulations.

train departed Warwick about 7:03 p.m. for Akron Junction with 49 freight cars and 2 cabooses. None of the crewmembers made notations on the profile document to identify the 11 cars set off at Warwick, or the 5 cars added to the train at Warwick. On the wheel report, the conductor identified the 11 cars set off at Warwick, but he did not enter any information on the wheel report to identify the 5 cars added to the train at Warwick. The conductor later said he intended to enter that information on the wheel report after arriving in Akron. Figure 2 lists the position of all cars in the train when it left Warwick and identifies the cars that were set off and added en route.

In addition to the documents that CSX required the conductor to carry with him, the conductor maintained a personal list of all cars involved in the train's movement. Whenever a car was set off or added to the train, he entered that information on his personal record. The conductor said he kept this list of cars "so that at any moment, if there is any question [to] arise, I can inform my head end [crew] exactly what we got in possible tonnage and so forth."

The crew reported no problems or irregularities while operating the train over CSX eastbound track No. 2 from Willard to Warwick, about 60 miles. The train passed three equipment defect detectors that provide an audible warning to the locomotive engineer while traveling over this section of track; no defect warnings were received from two of the detectors, and the third detector reported a radio malfunction.

The Accident

At Warwick, the train switched to Consolidated Rail Corporation (Conrail) northbound track No. 1. The train entered the Conrail track at mile post (MP) 27.2 and passed two dragging equipment defect detectors: one at MP 23.0 and the second at MP 16.7. No defect warnings were received.

The engineer reported that as the train approached MP 16.1, the train was "drifting" down a grade with the throttle in the idle position and with no brakes applied. He said the speed indicator showed that the train was traveling 42 mph. He stated further, however, that he believed the train was actually traveling about 40 mph--the maximum speed permitted on that section of track. He said that earlier in the trip he had checked the speed indicator on the lead locomotive unit (6124), and had calculated the actual speed of the train to have been about 2 mph slower than the speed displayed by the indicator.[6]

About 7:25 p.m., near MP 16.1 and the south end of Conrail's rail yard, the locomotives crossed a bridge over the Ohio Canal and passed through two switching turnouts.[7] The first turnout connected the northbound main track

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[6] Speed was calculated by noting the time elapsed between mile posts.

[7] A turnout is an area of track that contains a switch to direct a train from one track to another.

Cars set off before accident

Cars set off in Easton.

1.	ICG	978970	
2.	TTPX	80315	
3.	CPI	317106	

Cars set off in Warwick.

1.	ECUX	405280	
2.	BO	350077	
3.	CO	351022	
4.	BO	350977	
5.	ACFX	87256	
6.	UTLX	27831	Chlorine
7.	ACFX	19628	Chlorine
8.	TLDX	817067	Chlorine
9.	UTLX	28180	Chlorine
10.	ACFX	86995	Potassium Hydroxide
11.	ACFX	86134	Chlorine

Order of cars when train left Warwick and at time of accident

1.	RBOX	43456		
2.	TTPX	82333		
3.	TTPX	82745		
4.	UP	273208		
5.	CO	903042		Cars added to train in Warwick (no hazardous materials).
6.	PROX	78942		
7.	ACFX	81549		
8.	NW	178987		
9.	NW	178526		
10.	SBD	128362		Cars derailed in accident (cars 10-30 inclusive).
11.	CGTX	23079		
12.	WSOR	501027		
13.	WSOR	501003		
14.	WSOR	501011		
15.	MNPX	2071		
16.	PHD	2129		
17.	PHD	2158		
18.	CITX	34602	Butane	
19.	UTLX	88119	Butane	
20.	ZIPX	3382	Butane	
21.	CITX	33875	Butane	
22.	BCDX	474	Butane	
23.	GATX	83935	Butane	
24.	UTLX	804764	Butane	
25.	ACFX	17285	Butane	
26.	CITX	34944	Butane	
27.	WSOR	501004		
28.	WSOR	501030		
29.	NATX	23894		
30.	BO	350777		
31.	BO	356999		
32.	PAL	2193		
33.	MRS	2046		
34.	PHD	5015		
35.	TILX	300526	Butane	
36.	TILX	300529	Butane	
37.	ACFX	77100	Butane	
38.	TILX	300460	Butane	
39.	CITX	33831	Butane	
40.	BCDX	404	Butane	
41.	MRS	2090		
42.	GONX	310531		
43.	GTW	147637		
44.	MP	712197		
45.	ACFX	2406	Butadiene	
46.	CSTX	138839		
47.	CSTX	136624		
48.	GACX	56174		
49.	GACX	56152		
50.	SOU	523330		
51.	BO	904063	Caboose	

Figure 2.--Identification of cars involved in train movement.

to the southbound main track, and the second turnout connected the northbound main track to a parallel auxiliary track. The engineer said that when the locomotives passed through the switches he noticed "a good bit of lateral movement...more lateral movement that Sunday night than there had been on the Friday [before] that I had worked." He said that after he noticed the lateral movement, which he believed to have occurred near the trailing point of the first crossover switch, he was going "to apply--use some air [brake] because of this lateral movement," but an emergency application of the train brakes was automatically initiated before he was able to do so.

The brakeman, who rode in the lead locomotive with the engineer, said that the ride was rough at bridge 16 (over the Ohio Canal) and that they experienced lateral movement at that location every day. But, he added, "It didn't seem extreme." When asked specifically if there was more lateral movement on the day of the accident, the brakeman said, "Any time you have crossovers, there is always a little lateral movement. I did not take any exception to it...I don't believe it was much rougher than most of them."

The engineer said that after the train brakes applied in emergency he immediately released the independent air brakes to prevent the brakes from being applied on the engine. The brakeman looked back and saw what he believed to be a tank car lying on its side in the southbound track. He then saw a shower of sparks, a big flash, and fire.

At the time of the derailment, the train consisted of 4 locomotives and 51 cars. Twenty-one cars derailed, including nine tank cars containing more than 270,000 total gallons of butane, a highly flammable liquefied petroleum gas. Cars number 10 through 30 derailed (see figure 2).

Witnesses' Observations and Actions

The accident occurred near a B.F. Goodrich Chemical Company plant, and several tank cars of butane came to rest adjacent to B.F. Goodrich's building number 315 (figure 3). One of these tank cars (UTLX 88119) lost all of its butane (about 30,000 gallons) after sustaining a tear 15 feet 9 inches long in its sidewall. A second tank car (CITX 33875) lost butane through a 13-inch crack in its sidewall. A third tank car (ZIPX 3382) leaked butane through a valve in the dome. Tank car ZIPX 3382 was overturned and rested about 5 feet from the northwest corner of building 315; the tank car's pressure relief valve was obstructed by the ground and the car was involved in fire. Building 315 was 75 feet from the northbound track.

Building 315 housed a B.F. Goodrich latex manufacturing operation. That operation involved the use of acrylonitrile, butadiene, and styrene monomer, which were stored in tanks nearby (see figure 3). Additionally,

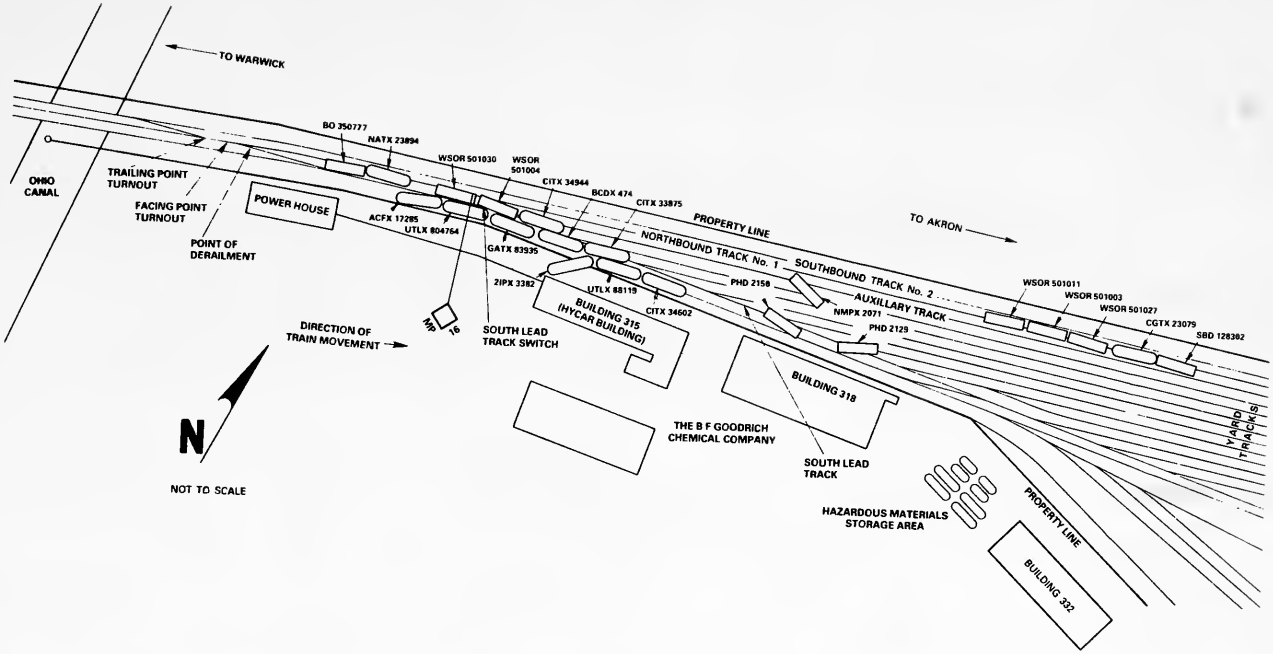

Figure 3.--The accident site.

refrigeration equipment inside the building, used to control temperatures during the manufacturing process, contained anhydrous ammonia.[8]

A B.F. Goodrich employee was on the roof of building 332, located 800 feet east of building 315, when he saw the train traveling past building 315. He said that when the train was opposite building 318, he saw a wall of fire develop on the north side of building 315 and that the flames were about three times as high as the four-story building.

A second B.F. Goodrich employee, who was in the facility's power house on the west side of building 315, felt a strong vibration in the floor. He looked out a window and saw a bright light coming through it, so he went to a door on the east side of the building and stepped outside. He said that he saw a tank car moving through the air in the direction of the northwest corner of building 315; he thought that it then hit the building and came to rest directly beneath an overhead exhaust pipeline that carried unreacted styrene monomer fumes from building 315 to the power house. He then directed a shutdown and evacuation of the power house. He said that flames filled the area between building 315 and the power house.

A third B.F. Goodrich employee, located in a control room on the third floor of building 315, heard a rumbling noise and looked to the north side of the building. Through a window he saw a wall of orange flames across the outside of the west half of the north wall. He stated that at first, he thought that the pipeline used to transport unreacted monomers to the power house had caught fire or exploded, but after checking gauges and 30 reactors[9] he determined that was not the case. As a precaution, he closed a valve on a pipeline that supplied butadiene to the fourth floor and left the building. Once outside the building, he saw derailed tank cars involved in fire. Believing the tank cars could explode, he reentered building 315 and switched controls for the unreacted monomers to the emergency mode.[10] He then left the building, went to the storage tank area, and closed valves in pipelines that supplied acrylonitrile, styrene monomer, and butadiene to facility buildings. He returned to building 315, turned down reactor temperature controls, extinguished a north wall insulation fire[11] with a facility hose, and left the building.

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[8] Characteristics of the chemicals mentioned in this paragraph are briefly described in the section, "Hazardous Materials Information."

[9] Equipment used for processing chemicals in the latex manufacturing operation.

[10] An action to slow the chemical reaction process.

[11] The fire was a result of butane burning and not from chemicals inside the building.

Emergency Response and Wreckage Clearing

Actions of Train Crewmembers.--When the train came to a stop, the flagman looked out the window of the caboose and saw a ball of fire over the B.F. Goodrich facility. He called the CSX Akron dispatcher on the radio, told him that they had a bad derailment, and asked him to stop trains in both directions. He told the dispatcher to call "haz mat" first, call the fire department, and then to call the Chessie [CSX] personnel because the accident was serious.[12] The flagman then walked past the rear of the train and set up signals to warn any approaching train to stop.

The conductor said that he picked up his consist,[13] profile, and waybills, and stepped off the caboose. He walked toward the front of the train to survey the damage, and to determine which cars were involved in the accident. He marked on his copy of the profile the first car that he saw remaining on the rails at the rear end of the train, and after talking to the brakeman by radio, the conductor also noted on his copy of the profile the number and location of the last car that remained on the rails at the front end of the train. With this information, the conductor said that he determined that 21 cars had derailed and that 9 tank cars of butane were the only hazardous materials cars involved in the derailment.[14] The conductor then disengaged the locking mechanism between the couplers on the last derailed car and the following car, which was not derailed, so that cars not involved in the derailment could later be pulled away from the accident scene. He then returned to the back of the train where he and the flagman attempted to chase spectators away from the accident site.

Immediately after the train stopped, the brakeman said that he stepped off the locomotive and walked ahead of the train to set up signals to warn any approaching train from the north to stop. He then returned to the locomotive, put on his coveralls, obtained the profile from the locomotive, and walked south toward the derailment to look for a fireman and to identify which cars were derailed. He found no fireman and decided that no one could get to the fire from that direction. He then disengaged a locking mechanism between the couplers of the eighth and ninth cars, and about 7:34 p.m., the engineer pulled the front end of the train forward about 400 feet.

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[12] The CSX Akron dispatcher stopped the movement of trains in both directions over that route and notified the Conrail dispatcher of the derailment.

[13] The list of cars in the profile document is referred to as a "consist" by train crewmembers and railroad personnel.

[14] Although the profile had not been revised to note that the tank cars of chlorine and potassium hydroxide had been set off before the derailment, the conductor knew that those cars had been set off before the derailment and he had noted the setoff of those cars on the wheel report.

About 7:53 p.m., the engineer, with the brakeman on board, pulled the front end of the train forward about 3/4 mile to an overpass at South Main Street. Afterward, they left the train and walked toward a fast food restaurant to get a soft drink when they saw a police car. They approached a police officer to make sure that emergency response personnel knew what was involved in the derailment and to identify themselves. About this time, the brakeman realized he had lost his copy of the profile. The police officer then drove the engineer and brakeman to see the fire chief.

Notification of Emergency.--About 7:25 p.m., Akron police officers, firefighters, and residents observed a large fireball in the area of the South Akron rail yard and the B.F. Goodrich Chemical plant. Because of the fire's proximity to the plant, several persons reported that chemicals from the plant were burning, and by 7:30 p.m., the Akron Fire Department and the Akron Police Department dispatchers were inundated with calls from persons reporting the fire or seeking information about the emergency.

A fire department lieutenant assigned to fire station 10, about 1 mile from the accident site, was one of the firefighters who saw the initial flash and fireball. He informed the battalion captain, who initiated an immediate fire department response to the B.F. Goodrich Chemical plant. Because the captain was aware that butadiene and other volatile chemicals were stored at the plant, he ordered all responding units not to proceed beyond the main gate of the B.F. Goodrich plant until the arrival of a chief officer from the Akron Fire Department.

About 7:27 p.m., a hazardous materials coordinator from the Akron Police Department was assigned to coordinate an evacuation and to control traffic. A police command post was initially established about 1/3 mile west of the accident site, but it was later moved to the east side of the accident site where the fire department had established an incident command post.

About 7:30 p.m., the CSX Akron dispatcher notified Conrail personnel at Warwick of the derailment and asked them to notify someone from Conrail at the South Akron yard. About 7:33 p.m., the CSX Akron dispatcher called the Akron Police Department to report the derailment; the police stated they already knew about the accident. The CSX Akron dispatcher then notified the CSX headquarters operations in Jacksonville, Florida, and supervisory personnel in the Akron area.

When a Conrail safety supervisor at home in Cleveland was notified about the accident, he instructed the Conrail Cleveland dispatcher to ask CSX to send a consist of the train to the Conrail Cleveland office. A consist was prepared by CSX personnel from the computer and was sent to Cleveland by facsimile equipment. The Conrail Cleveland safety supervisor then picked up the consist, dated February 26, 1989, 7:34 p.m., obtained self-contained breathing equipment, and drove to the accident site about 35 miles away.

Actions of Emergency Response Personnel.--About 7:32 p.m., the district hazardous materials chief (operations chief) of the Akron Fire Department arrived at the B.F. Goodrich Chemical plant. B.F. Goodrich personnel met him at the gate and told him that they were not certain what had happened,

but they suspected a tank car, possibly filled with latex,[15] had erupted. However, because of the immense flames, smoke, and the tremendous noise--which indicated to him that something was under pressure--the operations chief believed that the fire involved other products. The operations chief also knew that building 315 contained volatile, toxic substances because he had been at the plant several times during training to prepare for emergency situations. He initially established a command post near the entrance to the chemical plant and requested additional firefighters and equipment. The command post was later moved to a location about 3/4 mile east of the accident site.

The operations chief said that his first concern, if tank cars were involved, was the possibility of a BLEVE,[16] and he directed the fire department dispatcher to contact Conrail for information about the contents of cars in a nearby rail yard. The operations chief could not see if tank cars were involved in the fire because building 315 was between him and the railroad tracks. Therefore, he asked the fire chief, who was responding to the accident site, to go to a location on the west side of the accident site where he believed the fire chief could see the tracks, could confirm if tank cars were involved in the fire, and could identify the product or products involved. The operations chief also ordered B.F. Goodrich personnel to activate four unmanned facility monitors,[17] which were permanently aimed at the chemical company's hazardous materials storage tanks, and to protect the tanks from thermal exposure in case the incident worsened. He also activated the city's mass evacuation plan.[18]

A few minutes later, the fire chief reported to the operations chief that tank cars were involved in the fire and that they were near the building; however, he could not read placards or markings on the tank cars to identify the product or products involved (figure 4). By this time, the mayor of Akron had also responded to the accident site where he met the fire chief. The mayor later told Safety Board investigators that his role was not to make specific, detailed judgments on what actions should be taken at the scene, but rather to make certain that the safest alternatives were chosen when key decisions affecting public safety were made; for example, decisions

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[15] Finished product from the plant.

[16] Firefighting personnel often use the term BLEVE (boiling liquid expanding vapor explosion) to refer to the violent thermal rupture of a pressurized vessel that results in the instantaneous and violent release of burning gases.

[17] A monitor is a fixed or portable nozzle assembly used to direct a large volume of water for extinguishing fire or for cooling purposes, often referred to as a deluge.

[18] Areas adjacent to the accident site were evacuated immediately, and about 8:39 p.m. evacuation of a 1/2-mile radius was ordered based on the 1987 Emergency Response Guidebook of the U.S. Department of Transportation.

Figure 4.--Derailed tank cars adjacent to building 315.

concerning the size of areas that should be evacuated and the duration of evacuation.

Between 7:44 p.m. and 7:50 p.m., the Akron fire department called the CSX Akron dispatcher and requested information about products carried in cars involved in the accident. The CSX dispatcher said that the train had a total of 14 tank cars of butane: 8 cars of butane near the head of the train followed by miscellaneous cars and then 6 more cars of butane.[19] Also, the dispatcher said that 1 tank car of butadiene was near the rear of the train. However, at 8:02 p.m., the Akron CSX dispatcher's office called CHEMTREC[20] and reported that 9 tank cars of butane were involved in the derailment; he then gave to CHEMTREC the correct car numbers for those 9 cars.

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[19] Actually, there were 15 tank cars of butane in the train: 9 near the front of the train and 6 that followed miscellaneous cars.

[20] Chemical Transportation Emergency Center operated by the Chemical Manufacturers Association.

About 8:17 p.m., the engineer and brakeman met with the fire chief in the fire chief's car. At that time, the brakeman said that butane was the only hazardous material transported in the derailed tank cars, that butadiene was not involved in the derailed cars, and that he had lost his copy of the profile.

Because the fire chief wanted to see the paperwork to confirm that only butane was involved in the derailment, he drove the brakeman back to the accident site to look for the lost profile. When they did not find the profile, the brakeman contacted the conductor by radio to let the fire chief talk with him about the cars involved in the derailment.

The conductor said he told the fire chief that according to his records, the only cars involved in the derailment that contained hazardous materials were nine tank cars of butane. During the conversation, the conductor knew he was talking to the fire chief, but the fire chief thought he was talking to someone at the rail yard. The fire chief was not aware, and neither the engineer nor the brakeman informed him, that a conductor and a flagman had been at the rear of the train and that the conductor had a second copy of the train profile. The conductor was aware that the brakeman had lost his copy of the profile, but he never informed the fire chief that he had a second copy at the rear of the train. Based on information from his conversations with the brakeman and the person on the radio (the conductor), the fire chief, at 8:38 p.m., told the operations chief by radio that nine cars of butane were involved in the derailment and that some of those cars were involved in fire.

The CSX Akron Junction duty officer (trainmaster) arrived in the vicinity of the accident site about 8:20 p.m. and found the four locomotives and eight cars at the front of the train (which had not derailed) parked on a track near South Main Street; however, he saw no train crewmembers and could not contact them by radio at that time. About 8:35 p.m., the trainmaster was able to contact the flagman by radio. He asked if the conductor had given the fire department information about the hazardous materials that were involved in the derailment. The flagman responded yes, recalling the conductor's radio conversation with the fire chief and brakeman. As a result of his conversation with the flagman, however, the trainmaster incorrectly assumed that the conductor was with the fire chief and that the conductor had provided the fire chief all necessary information. The trainmaster later told the Safety Board that after his conversation with the flagman, he felt certain that the fire department knew what materials were involved and he decided to go to Akron Junction to make arrangements for the Federally mandated drug testing of the train crew, retrieval of speed tapes from the locomotives, and crew interviews.[21]

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[21] A second CSX trainmaster arrived at a roadblock near the accident site about 8:30 p.m. He was directed to the fire chief and expressed his need to enter the accident site to assess what type of equipment would be needed for cleanup operations. He was denied entry and told to stay with an assistant fire chief until he was released about 10:30 p.m. to take train crewmembers to the hospital for drug testing.

About 8:41 p.m., the engineer took the four locomotives and front eight cars of train D812-26 (which had not derailed) to the CSX Akron Junction, about 4 miles north of the accident site, and the fire chief and brakeman returned to the incident command post from the accident site about 8:55 p.m.[22] As had been instructed by the trainmaster, the conductor left the waybills for the derailed cars in the caboose at the accident site, and he took the train profile waybills for the non-derailed cars, emergency response guidance, and wheel report to the Akron Junction yard with him. Neither the conductor nor the flagman met with emergency response personnel before leaving the accident scene together by taxi to go to Akron Junction.

Also about 8:55 p.m., the Conrail safety supervisor from Cleveland arrived at the accident site and said he was taken to the incident command post where the brakeman used the facsimile copy of the train consist brought by the supervisor to identify cars that had been set off before the accident, including all five tank cars of chlorine and one tank car of potassium hydroxide. The operations chief, however, was not convinced that only butane was involved in the derailment, and later told Safety Board investigators he did not remember that a train crewmember (the brakeman) had been present to help identify cars listed on the safety supervisor's copy of the consist that were involved in the derailment. Therefore, about 9:20 p.m. the operations chief said that he and the Conrail safety supervisor went to the accident site and compared the numbers on cars in the train to car numbers on the safety supervisor's copy of the consist. Even then the operations chief said he was not fully confident that the tank cars of chlorine had been set off before the accident.

The CSX trainmaster received the train profile and wheel report from the conductor about 9:45 p.m., at the Akron Junction yard, and he had learned that the fire department was still concerned about the possibility of chlorine being involved in the derailment. He recognized the need to get the conductor's copy of the profile into the hands of the incident commander, drove to the incident command post, arriving at 10:15 p.m., and offered the incident commander the conductor's train papers. The incident commander (fire chief) referred him to the operations chief. The trainmaster explained to the operations chief, to whom he was directed, that the chlorine cars had been set off from the train before the accident, and that the butadiene car was not involved in the derailment. According to the operations chief, he then felt confident that chlorine was not involved in the derailment and decided he did not need the conductor's copy of the train papers. At that

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[22] The fire chief was the incident commander. Whenever it was necessary for him to leave the accident scene, the operations chief acted as incident commander.

time, the operations chief told the CSX trainmaster to pull the rear cars of the train (those that were not derailed) away from the accident site.[23]

Meanwhile, about 10:02 p.m., unmanned monitors were activated to direct water onto the tank cars involved in fire to cool them. The operations chief said that if the chlorine had been involved in the fire, he would not have used water to cool the cars because he believed that a runoff of chlorine could contaminate water supplies and produce chlorine gas. The operations chief also stated that the fire department probably could not have begun putting water on the fire any sooner than they did because the nearest water supplies they could use were 2,000 feet away.

By 11:00 p.m., a 1 1/4-square-mile area had been evacuated involving about 1,750 persons[24] (figure 5). City schools and Akron University were closed, and city bus service was cancelled for the next day because the city bus garage was inside the evacuated area and not accessible to employees.

Assessment of Conditions by Hazardous Materials Personnel.--About 11:30 p.m. on February 26, the CSX division manager for hazardous materials (CSX hazardous materials supervisor) arrived at the accident site from Detroit, Michigan. He had previously met with and provided training to Akron Fire Department personnel and therefore was recognized by the operations chief. He stated that when he arrived, the issue of chlorine cars involved in the derailment was raised; he told the operations chief that all chlorine cars had been set off from the train before the accident.

About 11:45 p.m., the CSX hazardous materials supervisor entered the derailment site to assess the damage to the tank cars. As a result of this inspection, he made the following observations: (1) tank car UTLX 88119 was probably in tact with no evidence of leakage; (2) flames were burning at one end of tank car CITX 33875; and (3) flames were burning near the dome of tank car ZIPX 3382, which was overturned; he estimated that one end of this car was located 4 to 10 feet from the northwest corner of building 315 (figure 6). He took notes on the position of each tank car and later constructed a diagram of the car positions. While at the derailment site, the CSX hazardous materials supervisor also observed that firefighters were on the roof of building 315 fighting a roof fire, and that the ground fire from released butane had been extinguished. About 1:00 a.m. on February 27, two B.F. Goodrich employees were allowed to enter building 315 to check the cooling system that controlled reactions of butadiene and acrylonitrile in the latex manufacturing process. The cooling system functioned properly throughout the incident. According to the B.F. Goodrich plant manager, had

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[23] The rear cars of the train were pulled back to Warwick about 1:45 a.m. the next morning, February 27, 1989.

[24] Residents were not allowed to return to this area until 6:00 a.m. on February 28.

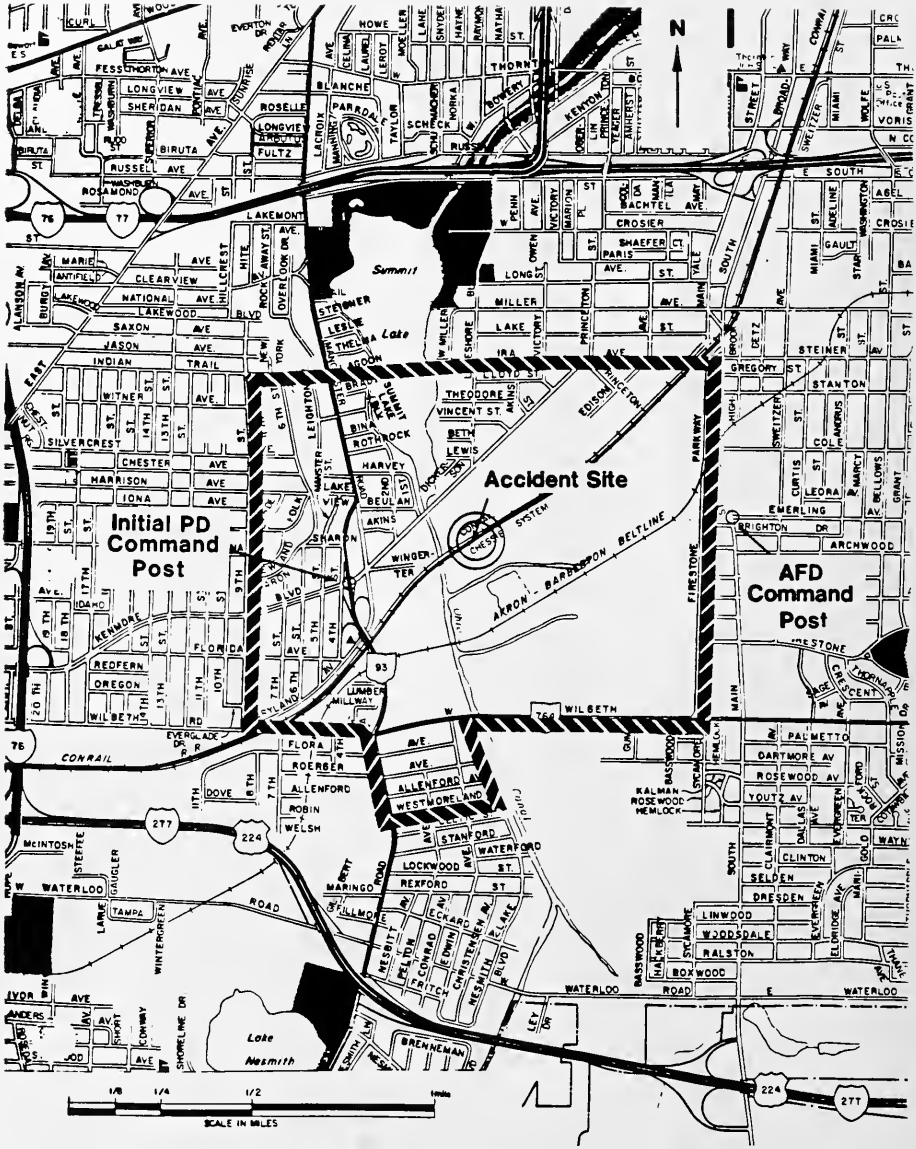

Figure 5.--Boundary of evacuation area ( ). (Adapted from: Highway map of Summit County, Ohio, 1986. Summit County Engineers Office, Akron.)

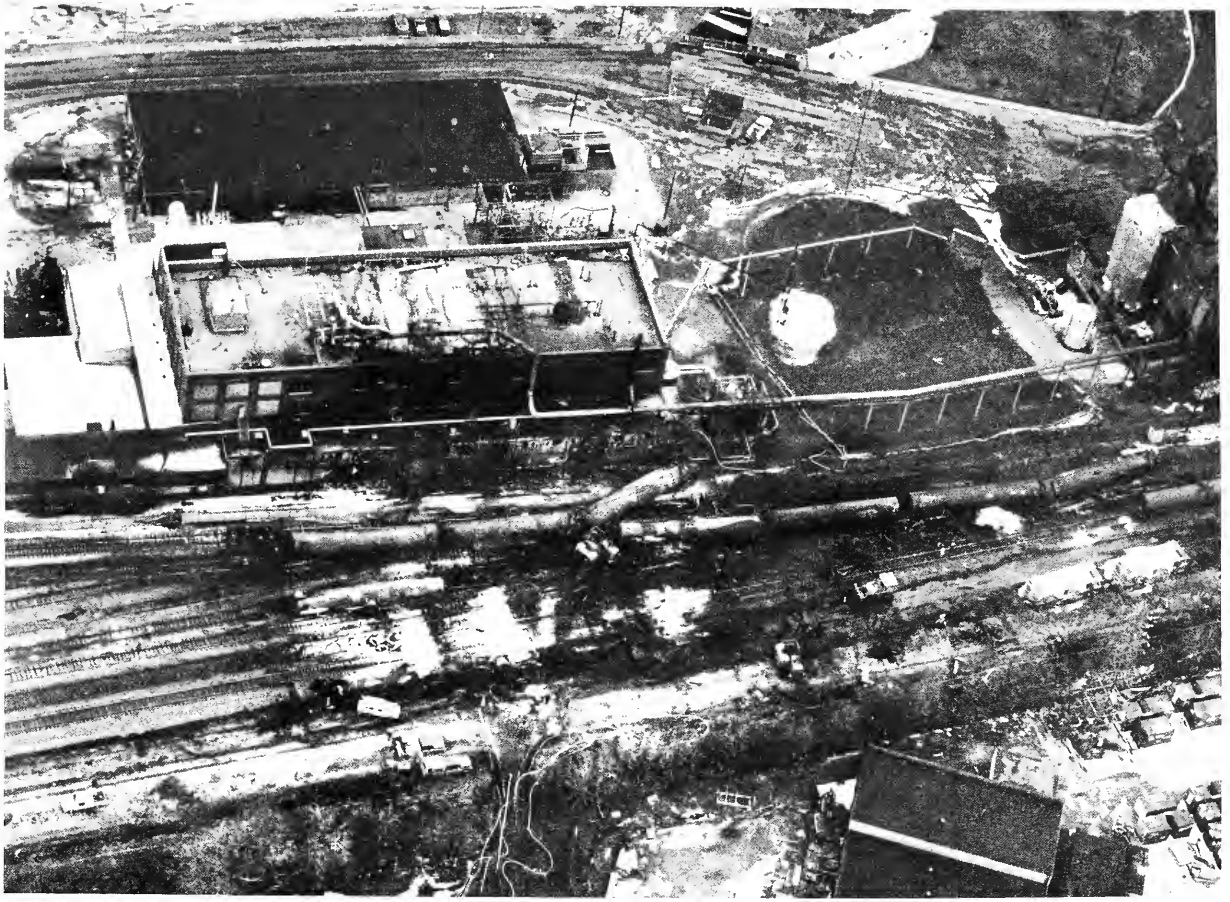

Figure 6.--Aerial view of derailment site. Some tank cars had been moved during wreckage clearing operations.

the system failed, chemicals involved in the manufacturing process could have heated naturally (by chemical reaction, polymerization), and vented toxic gases through the roof of the building.

After returning to the command post, the CSX hazardous materials supervisor expressed his concern to the operations chief that the overturned tank car (ZIPX 3382) had a fire near the dome, and that the pressure relief device, equipped on top of the car, may not function because of the orientation of the car. Without proper functioning of the device, he said there was potential for a violent thermal rupture of the tank car.

Meanwhile, a CSX superintendent of operations and the CSX Detroit division manager (in charge of the incident response for CSX) had arrived at the command post. These two men entered the derailment site with the CSX hazardous materials supervisor and a representative of the Association of American Railroads' (AAR) Bureau of Explosives. As a result of their inspection to assess the conditions, the CSX division manager told the fire department that it was critical to roll tank car ZIPX 3382 upright to lessen its potential for violent rupture. However, the CSX personnel insisted that Ashland Petroleum personnel be called to give an assessment.[25]

Wreckage Clearing Operations.--According to fire department personnel, throughout the incident, the city controlled the fire and activities at the scene, but it relied on the CSX for guidance and as the technical experts on wreckage clearing operations. The CSX division manager said that it was obvious the fire department had a lot of faith in the CSX hazardous materials supervisor because of his previous training with the city. (See section "Emergency Preparedness" for information on training.) The operations chief said that the city had no expertise to tell the railroad how to move the cars: "We had to leave that to their knowledge and ability."

About 5:15 a.m, the fire department allowed CSX mechanical personnel to begin clearing a path to tank car ZIPX 3382 to prepare for rolling the car upright after the arrival of Ashland's personnel. According to the CSX division manager, each tank car was inspected and assessed to be safe to move by the CSX hazardous materials supervisor, the Bureau of Explosives representative, and a wreckmaster from either R.J. Corman Railroad Construction or Hulcher Service, Inc. (CSX-contracted wreckage clearing companies) before being moved.

Ashland personnel from Ashland, Kentucky, arrived at the command post about 8:00 a.m. They completed an assessment of tank car ZIPX 3382 about 10:00 a.m. and agreed that tank car ZIPX 3382 should be rolled upright.

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[25] The butane was en route to the Ashland Petroleum facility in Canton, Ohio. Ashland Petroleum was requested to send a team to the scene. The company initially told emergency response personnel that a team would be onsite at daybreak but then stated they would wait until morning and provide whatever assistance was needed.

According to the CSX general foreman from Willard, who oversaw the CSX mechanical wreckage clearing operations and who supervised the CSX wreckmaster, CSX mechanical personnel had assessed rerailing the tank cars, and they were concerned about the ability of damaged tank car body bolsters to support the weight of the tank cars. The general foreman also said that heavily damaged tank cars are very difficult to retruck (to place back onto wheelsets) after a derailment. He said that during early discussions of wreckage clearing plans for this accident, his first choice was to set the tank cars in a clearing to be off-loaded; he assessed the process for stabilizing tank cars on wheelsets as "dangerous--not the preferred method." He said he knew of no equipment available to determine if damaged body bolsters can provide adequate support on reassembled tank cars after the bolsters are involved in an accident. Instead, he said, personnel had to rely on visual inspections and experience.

According to the CSX division manager, after assessments and discussions among CSX supervisory personnel, the AAR Bureau of Explosives representative, and the Ashland representatives, the group concluded that the safest action to take would be to transport the rerailed butane tank cars to a fixed facility for off-loading. The CSX general foreman said that the plan was to transport the tank cars to a fixed facility by loading the tank cars onto trucks (wheelsets) because flatcars (large enough to hold the weight of the tank cars) were not readily available.

At that time, the Ashland representatives said that rerailed butane tank cars would be accepted at Ashland's fixed facility in Canton, Ohio, the cars' original destination; and the Norfolk Southern Railroad, the rail carrier serving the Ashland facility at Canton, agreed to accept and transport the tank cars. Therefore, CSX planned to rerail the nine tank cars, to move them about 4 miles to CSX's Akron Junction yard, and then to more permanently secure the seven tank cars still containing butane to their trucks for the 16-mile trip to Canton.

The CSX division manager advised the fire department of the CSX plan to rerail the damaged tank cars and to move them to the Akron Junction yard; he did not explain any hazards that could be involved in moving the wrecked train, or provide any alternatives--such as loading the damaged tank cars onto flatcars instead of wheelsets. The operations chief told the Safety Board that he agreed with the CSX's plan to move the tank cars to the Akron Junction yard, and that he continued to rely on the railroad as the technical expert in these matters. According to both the fire department and the CSX, neither considered it safe to transfer butane between tank cars at the accident site because of the continuing fire from one tank car (CITX 33875) and the risk to the B.F. Goodrich chemical plant. The operations chief stated that he insisted that the cars not be unloaded at the accident site because of the continuing fire from tank car CITX 33875. (The car continued to burn until 3:00 p.m. on March 3, 5 days after the derailment.)

About 3:25 p.m. on February 27, tank car ZIPX 3382 was rolled over to provide access to the dome cover. A butane leak was found at the packing beneath a valve attached under the dome cover. The valve handle was

tightened about 1/4 turn, the butane leak was stopped, and the butane fire at this location was extinguished.

About 4:05 p.m., the CSX senior risk manager at CSX headquarters in Jacksonville, Florida, contacted the Federal Railroad Administration (FRA) of the U.S. Department of Transportation (DOT) in Washington, D.C., requesting permission to move the damaged tank cars as a hospital train[26] from the Akron Junction yard to Ashland's facility at Canton. The FRA granted permission on the condition that a buffer car be placed between each tank car. The CSX risk manager did not request permission to move the damaged cars from the accident site to the Akron Junction yard; he later said he considered that movement of cars a part of the emergency.

About 8:55 p.m., tank car UTLX 88119, which was believed to be full of butane, was rolled upright. As the car was rolled, a coupler and attached drawbar dropped from the side of the tank; a penetrating gash 15 feet 9 inches long (including a hole about 8 inches by 8 inches) was visible in the side of the tank car shell, which was found to be empty (figure 7).

The CSX hazardous materials supervisor later told Safety Board investigators that he was not aware of any mechanical tests or examinations that were available to help assess the structural integrity of tank cars after a derailment. He said he depended on previous experience to evaluate the condition of derailed cars, and he acknowledged that because the full extent of damage to a tank car's integrity may not be visible, there will always be some risk when wreckage clearing operations involve tank cars of hazardous materials.

By 3:00 a.m. February 28, seven of nine tank cars had been rerailed and were ready for transport to the Akron Junction yard.[27] CSX and Conrail representatives inspected the cars and agreed that they were safe to be moved. Three locomotives were connected first to two hopper cars serving as buffers and then placed in front of the seven tank cars. A wreck crane, a tool car, and a fourth locomotive followed.[28] Six of the tank cars were coupled together using chains because their couplers and/or drawbars were broken or missing. The tank cars had been chocked (shimmed) with wood between missing or damaged body bolsters and the trucks (wheelsets). The air brake equipment was damaged and was not functional.

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[26] The term "hospital train" refers to cars that were damaged in an accident and that do not meet all FRA safety regulations.

[27] The remaining two tank cars were to be moved to Akron Junction at a later time.

[28] The following units served as a barricade in the event that a tank car became free; the units also carried tools for use if needed.

Figure 7.--Tank car UTLX 88119.

Second Event Involving Tank Cars.--About 4:00 a.m. on February 28, the wreck train began its movement to the Akron Junction yard. The plan was to move at about 2 to 3 mph, walking speed. Conrail and CSX employees rode on the train to observe the tank cars. As the engines began to pull the train, a chain between the first and second cars came loose; it was reapplied and adjusted. The engines again began to pull and the same chain broke. The cars were again chained together, and after moving about 1/2 mile, the chain between the first and second cars broke again. Another chain was then applied and the tank cars were inspected. Tank car GATX 83935 was found to be leaning, and when the train moved to take up slack, sparks were seen beneath the car. A wheel was found to be cutting the tank car steel jacket but it was not believed to have damaged the tank shell; therefore, jacks were used to raise the tank and additional wooden chocks were added between the tank and the truck.

As the train began to move a third time, two CSX employees and a Conrail employee walked beside the train to observe the tank cars. About 7:55 a.m., the train entered a long, superelevated curve;[29] about 1/4 mile into the curve (about 3 1/2 miles north of the original accident site), the crew observed tank car ZIPX 3382 rock and then roll off its trucks and onto the ground between the two mainline tracks (figure 8). A body bolster on the leading end of the car, supporting the tank car on the truck, had broken. A CSX supervisor within 30 feet of this tank car said there had been no warning of trouble.

Emergency Response to the Second Event.--CSX and Akron fire department personnel checked the tank car for leaks using explosimeters; no leaks were found. Initially, the fire department wanted to evacuate a 1,500-foot radius from the site of the second event. The CSX hazardous materials supervisor, however, convinced the fire department to evacuate only the adjacent city blocks; four houses and two businesses were evacuated, requiring 35 persons to leave the area. The integrity of the tank car was assessed by CSX, Bureau of Explosives, and Ashland representatives. Following discussions between city officials and CSX personnel, the tank car was lifted back onto its trucks, and again chocked with wood between the tank shell and the trucks. The tank cars were moved to the Akron Junction yard, one or two at a time.

The second event raised the city's concern about actions taken by the CSX to clear the wreckage. The mayor said that after the second event, his role changed out of necessity and that the city implemented "good, down-home common sense" rather than assume that the railroad was moving the cars by the safest possible method. He said that initially the city did not have a sense of authority to change plans affecting technical wreckage clearing activities, and that the city trusted and believed that someone with the proper expertise and knowledge was overseeing those operations. However, although continuing to rely on the railroad as the wreckage clearing experts after the second event, the city officials demanded an explanation of every detail and required several changes affecting cleanup activities. The mayor said that in spite of the second accident, the CSX personnel were cooperative throughout the clearing operations and he believed they were sincere in trying to safely clear the wreckage.

The mayor said, however, that he was less than satisfied with the role of the FRA because agency personnel failed to notify the city of its presence onscene until after the second event. He believed that the FRA should have helped the city to determine if the damaged tank cars were capable of being safely moved from the accident site to the Akron Junction yard, 4 miles away, because the city had no expertise to determine if wreckage clearing activities proposed by the CSX were safe.

Within an hour after the derailment, the FRA had dispatched four persons to the accident site to investigate the cause of the derailment, to observe actions taken, and to assure that those actions were in compliance

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[29] In a superelevated curve, one track is higher than the other to aid in controlling lateral forces on the train as it moves through the turn.

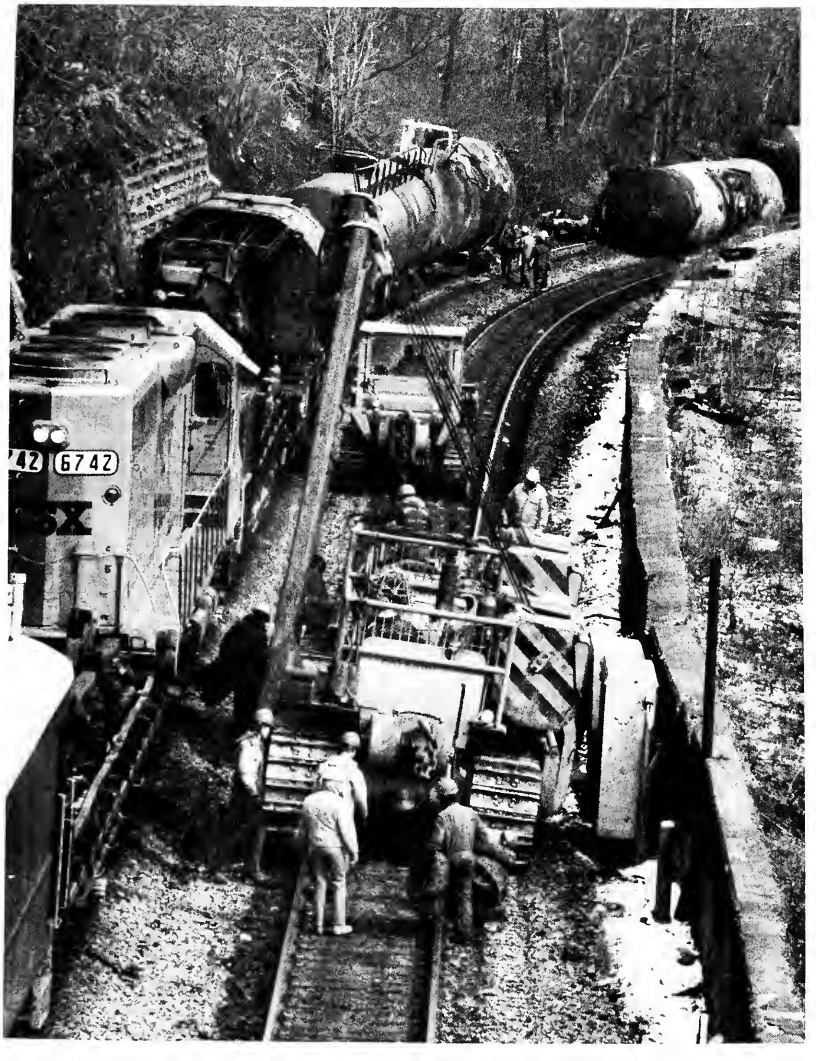

Figure 8.--Site of second event.

with the Federal regulations. The FRA's regional director stated, "It's the FRA's policy to not allow Federal personnel to offer instruction, advise or become involved in any advisory capacity to a railroad carrier, shipper, emergency personnel, including cities, during wrecking or clearing operations." The regional director also said, however, that if FRA employees saw a company preparing to lift a tank when they believed that action to be dangerous, they would discuss the matter with local officials.

After the second event, the CSX division manager explained to city officials that there were three options for further handling of the damaged tank cars: (1) transfer the butane to other tank cars at Akron Junction, then move the trans-loaded cars to Canton; (2) move the damaged tank cars on to Canton as a wreck train; and (3) load the damaged tank cars onto flatcars for transport to Canton. The city officials opposed transferring the butane at the Akron Junction yard because doing so would expose a third area of the city to risks and would require another (precautionary) evacuation. The mayor also expressed concern about allowing the damaged tank cars to leave Akron because it would expose others to risk along the route. The CSX division manager recommended transferring the butane from the damaged tank cars at a fixed facility, where specific safety systems were installed that would minimize the risk of a major problem. Meanwhile, CSX personnel had located several 100-ton flatcars owned by the Department of Defense (DOD) and arranged for the flatcars to be transported to Akron Junction. CSX considered it safer to move the damaged tank cars to Canton on flatcars, rather than on wheel sets, and selected this option; Akron officials did not object. After determining that the tanks loaded on flatcars could be off-loaded at the facility, Ashland and the Norfolk Southern Railroad said they would accept the tanks on flatcars.

Beginning March 2, CSX began loading the damaged tank cars onto the DOD flatcars at the Akron Junction yard for their movement to Canton. During the evening of March 3 and after several tank cars had been loaded onto flatcars, Ashland's vice president of operations told the CSX that it would not accept the damaged tank cars of butane at its Canton facility.[30] Therefore, on the morning of March 4, CSX personnel met with the mayor, related Ashland's decision, and offered two alternatives: (1) to transfer the butane to other tank cars at Akron Junction; or (2) to move the damaged tank cars to a remote site near Warwick to transfer the butane. (Other transfer locations were considered and determined to be unacceptable by the Akron fire department because of nearby hazards or the lack of adequate water supplies.) After consulting with city officials in Warwick and arranging to provide firefighting support from Akron, the mayor of Akron agreed to transferring the butane at the remote site near Warwick; the tank cars were moved to the transfer point that evening.

On March 5, about 6:30 a.m., CSX personnel and contract hazardous materials specialists met in Warwick to begin transfer operations; FRA

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[30] The CSX division manager said that Ashland gave no reason for declining to accept the damaged tank cars.

personnel were present to determine if regulatory requirements were met. The transfer operation began about 9:30 a.m.

On March 6, FRA personnel onscene advised the CSX that because of a severe wheel burn, tank car GATX 83935 could not be returned to Willard with the other tank cars after being emptied in Warwick. The CSX personnel disagreed, noting that inspections several days earlier revealed that the damaged area affected only the tank car jacket[31] and not the tank car shell, and that the full tank car had been permitted to move to Warwick. The FRA said that the car had moved to Warwick on an emergency basis (under 49 CFR 174.47(b)) and that the movement was controlled and restricted (under 49 CFR 215.9).[32] The FRA gave the CSX three choices for moving the car from Warwick: (1) Ashland must make a written request to the FRA in Washington, D.C., to move the car under a waiver; (2) CSX must make a written request to Washington, D.C., to move the car under a waiver; or (3) the empty car had to be purged. CSX elected to purge the empty car to complete the operations in a more timely manner. About 9:00 p.m. on March 6, 8 days after the derailment, all butane transfer operations were completed.

Injuries

Injury[33]	Railroad Personnel	Emergency Personnel	Residents/ Passersby	Total
Fatal	0	0	0	0
Serious	0	0	0	0
Minor	0	5	50	55
TOTAL	0	5	50	55

Of the 55 persons treated at five area hospitals, only 1 was admitted. He complained of difficulty breathing and chest pains; he had a history of a heart ailment and was admitted for observation.

One police officer stationed at the perimeter of the evacuated area at the first derailment site complained of dizziness. He was treated for chemical burns on the hands and face, and acute bronchorrhea. No evidence

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[31] The tank car jacket contains the thermal insulation surrounding the tank car shell.

[32] Title 49 CFR 215.9 allows defective freight cars to be moved to another location only for the purpose of effecting repairs, after it is inspected by an authorized person and determined to be safe to move the car. It allows a car to be moved to a location for unloading, if unloading the car is necessary for the safe repair of the car. If the car is empty, it may not be placed for loading.

[33] Injuries are defined in 49 CFR 830.2.

was found to indicate the source of the injuries, and no other emergency response personnel or residents reported similar symptoms.

Four firefighters, who were on the roof of B.F. Goodrich building 315, were treated for possible exposure to ammonia fumes. They were treated and released.

Fifty residents and passersby were treated for minor inhalation, coughing, and conjunctivitis. Some had eye irritation and most were treated for anxiety.

Damage

Damage to Rail Cars.--Of the 21 cars derailed in the accident, 16 cars were destroyed and 5 cars sustained moderate to heavy damage. CSX estimated the total damage to cars at $521,000.

The trucks beneath the tank cars of butane were stripped from the cars, and some tank cars did not stay coupled together as a result of broken coupler shelves and broken drawbars. Several tank cars sustained impact damage to head shields, jackets, and tank shells. There were no tank car failures as a result of fire exposure.

Four tank cars lost product as a result of derailment damage. The following is a summary of major damage to the nine derailed tank cars that transported butane:

UTLX 88119 (DOT specification 112J340W). The tank shell sustained a penetrating gash 15 feet 9 inches long (including a hole in the tank shell 8 inches by 8 inches). (See figure 7.) When the tank was lifted, a drawbar and attached coupler were observed to drop from the side of the tank. The tank car jacket sustained localized areas of severe heat damage. Two body bolsters were bent 90°. The A-end coupler was broken and separated from the drawbar. The A-end stub sill sustained a 10-inch crack.

ZIPX 3382 (DOT specification 112J340W). The tank car jacket displayed evidence of moderate burn damage, flame impingement, wrinkles and bulges from heat exposure, and tears. The top half of the B-end tank head sustained an impact that resulted in a dent, and about one-third of the head shield was missing (figure 9). The A-end coupler was missing and a body bolster at the B-end was missing.

CITX 33875 (DOT specification 112J340W). The tank car shell sustained a 13-inch crack in the leading edge weld that connected the body bolster to the tank shell. Directly in front of the crack, the tank sustained an impact that resulted in a dent in the shell more than 4 inches deep. The width of the impact marks were about the same width as a coupler. The A-end top shelf coupler was broken, and the bottom shelf was bent downward and toward the

Figure 9.--Tank car ZIPX 3382.

B-end of the car. The tank car jacket sustained tears and had evidence of flame impingement. The A-end head shield sustained an impact resulting in a dent about 5 inches across and two cracks, 7 inches and 12 inches long.

CITX 34602 (DOT specification 112J340W). An area about 8 feet long by 4 feet high was missing from the jacket on one side of the tank car. Some heat damage to the jacket was evident on the opposite side. The coupler shelves were broken on both ends of the car.

BCDX 474 (DOT specification 105J300W). The A-end head shield sustained three impact dents, one about 4 feet in diameter in the top half (figure 10). The jacket on top of the tank sustained dents of about 2 feet and 1 foot in diameter. The tank car jacket sustained tears and wrinkles from heat exposure.

Figure 10.--Tank car BCDX 474.

GATX 83935 (DOT specification 112J340W). The jacket sustained an area of light burn damage on one side, heavy burn damage on the dome and B-end head, and tears. On the bottom side of the tank car, there was a 2-foot wheel cut through the jacket; a portion of the jacket 1/2 inch wide by 8 inches long was heat fused to the tank shell. Three body bolsters were bent and one was displaced. The coupler and drawbar on the A-end was missing, and the stub sill was deformed.

UTLX 804764 (DOT specification 105J400W). The B-end coupler bottom shelf was broken off. The A-end stub sill was cracked. The jacket sustained impact dents and heat wrinkles from heat exposure.

ACFX 17285 (DOT specification 112J340W). The A-end coupler was missing. The B-end top shelf coupler was missing. The jacket sustained a tear, dents, wrinkles from heat exposure, and a dent and gouges in the B-end head shield.

CITX 34944 (DOT specification 112J340W). Both couplers were missing. The A-end stub sill was broken. The jacket sustained tears and gouges, and damage from flame impingement.

Damage to B.F. Goodrich Chemical Company.--B.F. Goodrich estimated total damage to the plant at about $1 million. Building 315 sustained fire damage from the butane fire to walls that faced the accident site, the roof, and two insulated pipelines. Moderate interior damage occurred, and electrical wiring that was subjected to heat had to be replaced.

Personnel Information

Conductor.--The conductor had been a railroad employee since June 26, 1963. He was promoted to conductor on April 15, 1967. He had worked as a regular conductor on the Willard-to-Akron assignment since October 1988 and had previously held the job about 3 years earlier.

The conductor had been off duty about 80 hours before reporting to work. He stated that he had slept about 9 hours Saturday night and had been awake about 5 hours before reporting for duty on Saturday.

The conductor stated that he had had no emergency response training other than the operating rules class and reading the book of rules. He passed his most recent Operating Rules Examination on June 2, 1988, with a score of 96 percent correct. The conductor said that railroad management had checked his operational performance several times by observing his actions and by asking him questions; however, he had never been questioned about actions he should take in the event of an emergency.

Engineer.--The engineer had been a railroad employee since August 13, 1966. He was promoted to engineer on July 15, 1976, and had been assigned to the Willard-to-Akron run since April 1988.

The engineer had been off duty 37 1/2 hours before reporting for work on the day of the accident. He said that he had slept about 7 hours the night before the accident, awakening about 8:00 a.m. on the day of the accident.

The engineer said that he had not been provided any specialized training for emergency response actions when hazardous materials were involved in accidents, and that he did not recall any operating rules test questions on the subject. He passed his most recent Operating Rules Examination on September 29, 1988, with a score of 88 percent correct.

Brakeman.--The brakeman had been a railroad employee since March 30, 1968. He was promoted to conductor on September 16, 1982, and had been assigned to the Willard-to-Akron run regularly for several months.

The brakeman had been off duty 37 1/2 hours before reporting for work on the day of the accident. He said that he had slept about 8 hours Saturday night and that he had been awake about 6 hours before reporting for duty on Sunday.

The brakeman stated that he had received no special training about what actions he should take when there was an accident involving hazardous materials; however, he said he knew the importance of locating emergency response personnel. He passed his most recent Operating Rules Examination on June 2, 1988, with a score of 94 percent correct.

Flagman.--The flagman had been a railroad employee since July 23, 1965. He was promoted to conductor on January 1, 1969, and had been assigned to the Willard-to-Akron run on a regular basis.

The flagman had been off duty 37 1/2 hours before reporting for work on the day of the accident. He said that he had slept from 8 to 10 hours Saturday night and that he had awakened at 9:00 a.m. on Sunday, the day of the accident.

The flagman stated that he had not been provided any specific emergency response training, and that he was not familiar with instructions in the timetable or operating rules that addressed what should be done with train papers after an accident. He passed his most recent Operating Rules Examination on June 9, 1988, with a score of 96 percent correct.

Hazardous Materials Information

The train carried about 450,000 gallons of butane: the 15 tank cars contained about 30,000 gallons of butane each. Nine of those cars (carrying about 270,000 gallons of butane) were derailed. An estimated 70,000 gallons of butane were consumed in the postaccident fire.

Butane is a liquefied petroleum gas and is classified by the DOT as a flammable gas. It has a flashpoint of about -100 ^{o}F, has flammable limits in air of between 1.8 percent and 8.4 percent. Although butane is not toxic, exposure to its vapors may cause dizziness or suffocation. Initial emergency response actions for accidents involving butane are contained in the DOT's 1987 Emergency Response Guidebook, Guide 22. (See appendix B.)

Three hazardous materials used in the chemical plant's manufacturing process were present in B.F. Goodrich Chemical Company's building 315 and were stored in tanks nearby: (1) butadiene, (2) styrene monomer (toxic, flammable liquid); and (3) acrylonitrile (flammable liquid and poisonous). A fourth hazardous material, anhydrous ammonia, a nonflammable compressed gas that is extremely corrosive to human tissue, was also present in the plant's refrigeration equipment used to control chemical reactions in the manufacturing process. Detailed information on the hazard characteristics of these materials is contained in excerpts from the U.S. Coast Guard's Chemical Hazardous Response Information System (CHRIS) Manual. (See appendix C.)

Rail Car Information

A postaccident inspection of the 21 cars involved in the derailment resulted in the identification of one car, WSOR 501003, with preaccident mechanical deficiencies. It was the 13th car in the train behind the

locomotives (cars in positions 10 through 30 were derailed). No evidence of prederailment mechanical deficiencies were found in components of the other cars.

Freight car WSOR 501003 was a 100-ton, two compartment covered hopper car (figure 11). It had a maximum cargo limit of 204,580 pounds, a light weight of 58,420 pounds, and was transporting about 197,580 pounds of sand at the time of the accident. It was originally built in October 1965 and was rebuilt in October 1988. After being rebuilt, car WSOR 501003 had made two successful round trips before the trip involving this accident.

After the derailment near the B.F. Goodrich plant, WSOR 501003 was observed turned over on its left side (direction of movement of the train). The A-end truck was separated from the car and was found about 50 feet south of the derailed car. The B-end truck, which was the lead truck in the direction of movement of the train, was also separated from and in line with the car. Heavy rail burns were observed on the left sideframe of the B-end truck and wheel marks were observed on the left side cross-ridge slope sheet of the car (figure 12). Additionally, the lead wheelset showed evidence of heavy chaffing and bluish discoloration on the steel rims and flanges. Some of the springs were dislodged from the right sideframe of the B-end truck assembly. Figure 13 identifies some pertinent components of a truck assembly, including the bolster and sideframes.

After WSOR 501003 was rolled upright on its own trucks, the truck bolster on the A-end of the car was observed to be a different design from the truck bolster on the B-end of the car, and that the truck bolster pattern numbers were different. The A-end pattern number was Scullin AAR-B-1925 and the B-end pattern number was Gould-B-9S-14EJ-BX.

Figure 11.--Freight car WSOR 501003.

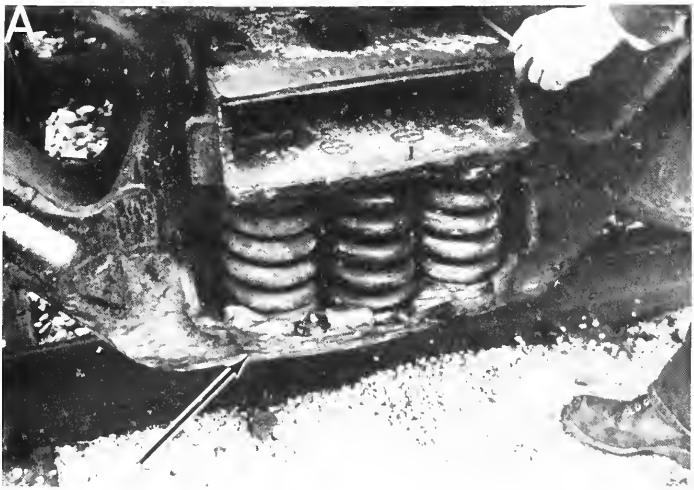

Figure 12.--Some of the damage observed on car WSOR 501003: (A) rail burn on sideframe, (B) wheel marks on slope sheet.

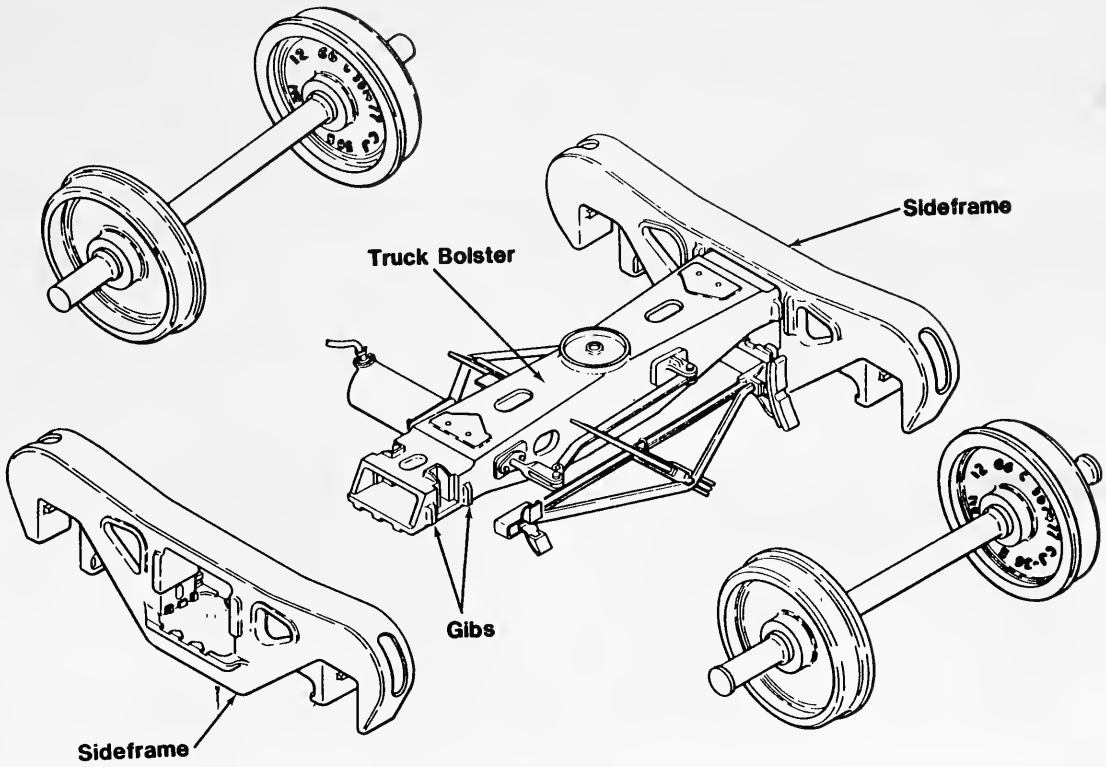

Figure 13.--Pertinent components of truck assembly.

Rule 47(B)(1)(a) of the Field Manual of the AAR Interchange Rules adopted by the AAR's Mechanical Division, Operations and Maintenance Department, states that truck bolsters must not be used if they do not have AAR identification marks or pattern numbers. Rule 47(B)(2) states that truck bolsters arranged for "wide land" bolster rotation stops are not interchangeable with bolsters incorporating the standard rotation lug. The B-end truck bolster on car WSOR 501003 (Gould-B-9S-14EJ-BX) was a wide land design, and it did not have AAR identification marks or pattern numbers.[34]

The gib clearance of the A-end truck was noticeably different from the clearance of the B-end truck. (A gib clearance is the space between the truck bolster gibs and the sideframes; it allows the truck components to guide the truck through the contour of the rail as the wheels of a car follow the track.) Total lateral gib clearance of the A-end truck was a maximum of 1 inch at each location measured; total lateral gib clearance of the B-end truck exceeded 3 inches at each location measured. Figure 14 illustrates the specific gib clearance measurements recorded for the B-end truck. Figure 15 shows the gib clearance visible outside the sideframe; the additional gib clearance inside the sideframe is not visible in the photograph.

Rule 47(A) of the Field Manual of the AAR Interchange Rules provides maintenance and gauging standards for truck bolsters. The rule states that when wheels are changed or trucks are dismantled, bolster gibs must be measured before disassembly, and when wear exceeds limits of 1 1/2 inches between the bolster and truck sideframe (for the type equipment installed on WSOR 501003), the equipment must be repaired to maximum nominal clearances between the bolster and truck sideframes of 1/2 inch inside and 1/2 inch outside. The trucks on both ends of WSOR 501003 had been dismantled when the car was rebuilt. The FRA has no safety regulations that address gib clearances between bolsters and truck sideframes.

The B-end truck bolster had originally been designed for use with friction journal bearings; however, letters "RB" cast in the truck bolster (separate from the pattern number) indicated that the bolster had been modified to accept journal roller bearings. The sideframes on the B-end and the A-end of the car were standard, and built for 6 1/2-inch by 12-inch journal roller bearings. The A-end and B-end trucks had been manufactured by ASF Ride Control, were equipped with seven coil cluster D-3 springs, and were set on 36-inch wheels.

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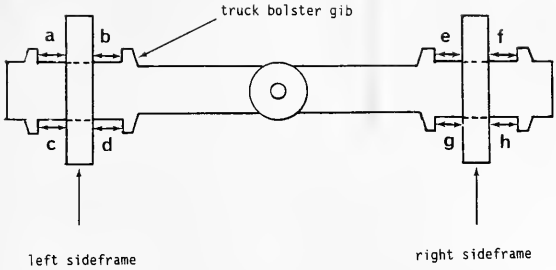
[34] There are two designs of bolsters: wide land and standard rotation lug. Each design requires a certain sideframe; a bolster of one design is not to be used with the sideframe for the other design. The B-end truck on car WSOR 501003 had sideframes designed for a standard rotation lug bolster instead of sideframes designed for a wide land bolster.



a = 2 inches	e = 1 7/8 inches
b = 1 1/4 inches	f = 1 1/4 inches
a + b = 3 1/4 inches	e + f = 3 1/8 inches
c = 2 inches	g = 1 3/4 inches
d = 1 3/16 inches	h = 1 3/8 inches
c + d = 3 3/16 inches	g + h = 3 1/8 inches

Figure 14.--Gib clearances measured between truck bolster gibs and sideframes on the B-end of WSOR 501003.

Figure 15.--Gib clearance visible outside the sideframe.

After car WSOR 501003 was rerailed and after its load of sand was leveled, the side bearing clearances were measured. (A side bearing clearance is the distance between a side bearing roller on a truck and a side bearing plate attached to the car body bolster above the roller; this clearance is illustrated in figure 16.) (One of the two truck side bearing rollers on the A-end right side was missing.) The measurements were as follows:

B-end Truck

Left Side (BL)	11/16 inch
Right Side (BR)	4/16 inch
Total (B-end)	15/16 inch[35]

A-end Truck

Left Side (AL)	8/16 inch
Right Side (AR)	2/16 inch
Total (A-end)	10/16 inch

Diagonal Computations

BL plus AR	13/16 inch[35]
BR plus AL	12/16 inch

FRA safety regulations (49 CFR 215.119(c)) prohibit a railroad from placing into service, or continuing in service, a car if any of the following conditions exist:

(1) Part of the side bearing assembly is missing or broken;

(2) The bearings at one end of the car, on both sides, are in contact with the body bolster (except by design);

(3) The bearings at one end of the car have a total clearance from the body bolster of more than 3/4 (12/16) of an inch; and

(4) At diagonally opposite sides of the car, the bearings have a total clearance from the body of more than 3/4 (12/16) of an inch.

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[35] Maximum clearance permitted by FRA regulations is 3/4 (12/16) inch. There is no minimum clearance; however, constant contact is not permitted for the type of bearing used on WSOR 501003.

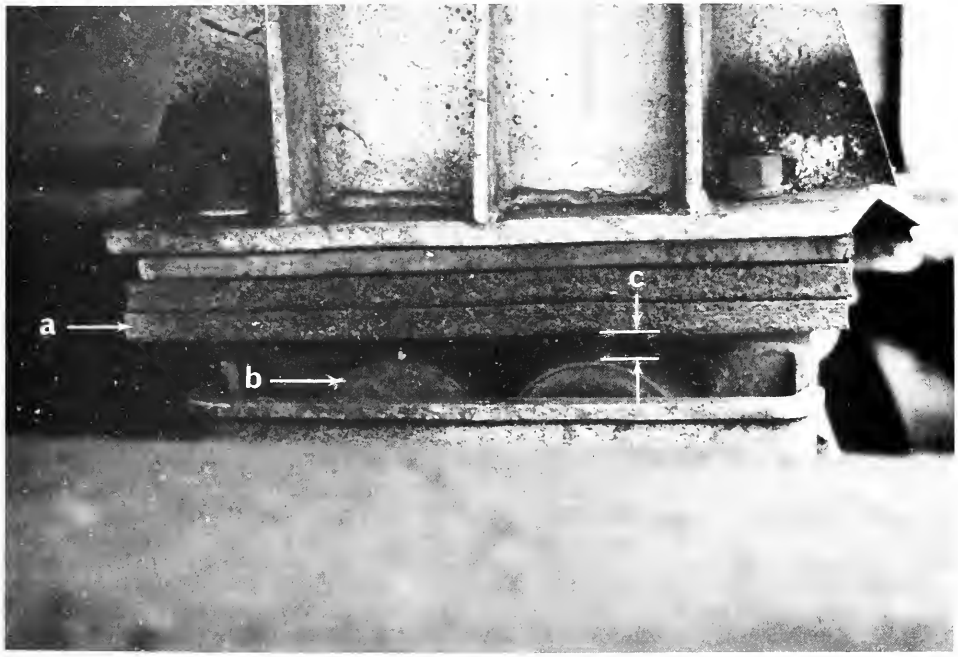

Figure 16.--Components of a side bearing: (A) the side bearing plate attached to the car body bolster, (B) the roller attached to the truck, and (C) the side bearing clearance in-between.

The Field Manual of the Interchange Rules of the AAR, Rule 47(E)(2), however, states that side bearings must have 3/16-inch minimum to 5/16-maximum clearance. (This clearance does not apply to constant-contact type side bearings.) The AAR considers the FRA regulations to be safety standards, and it considers the AAR rules to be maintenance standards that are designed to identify and correct problems before the FRA regulations are violated. The AAR considers the FRA maximum side bearing clearance to be safe.

Further visual inspection of car WSOR 501003 disclosed previous cracking in the A-end, right side, body bolster diaphragm where it had been welded to the center sill. The cracks were progressing toward the outer edge of the car. A mixture of common and high tensile bolts secured the body center

plate to the car.[36] Additionally, the body bolster wear plates on the B-end of the car displayed evidence of pounding or striking.

Car Repair and Rebuild Information

Car Repair Shop of Northern Rail Car Corporation.--The WSOR 501003 covered hopper car was one of 36 similar 100-ton hopper cars rebuilt several months before the accident at a contract car repair shop owned by Northern Rail Car Corporation (NRCC). In addition to WSOR 501003, another 4 of the 36 rebuilt hopper cars were involved in the derailment. The 36 rebuilt hopper cars were identified as car numbers WSOR 501001 through 501036.

The 36 covered hopper cars had been purchased by the Northern Rail Car Leasing Company of Cudahay, Wisconsin, in April and June 1988. The cars were taken to Cudahay, a suburb of Milwaukee, where they were rebuilt at the NRCC freight car repair facility. It offers general freight car repairs, major wreck repairs, and locomotive repairs as a contract repair shop. Additionally, the company operates a wheel shop, designs and builds special equipment cars, and offers a mobile repair service. The repair facility has been under its current ownership since April 1986.

The car repair shop estimated that about half of its work in 1988 was performed for the Wisconsin & Southern Railroad Company of Horicon, Wisconsin, and the Northern Rail Car Leasing Company of Cudahay. The Wisconsin & Southern Railroad Company operates as a railroad over 147 miles of track between Northern Milwaukee and Oshkosh, Wisconsin. In February 1989, it was operating 3 locomotives, had about 350 cars, and had been under its current ownership since August 1988. The three companies--NRCC, the Wisconsin & Southern Railroad Company, and the Northern Rail Car Leasing Company--were owned by the same person.

Between March 3, 1989, and April 6, 1989 (after the accident), CSX inspected 24 of the 36 hopper cars rebuilt by NRCC found moving on the CSX system but that had not been involved in the accident on February 26; special attention was given to side bearing condition and clearance, and truck bolster lateral gib clearance. Of the 24 cars, 3 had side bearing clearances that exceeded FRA limits for diagonally opposite ends, and 1 car had no side bearing clearance at the left or right side on one end of the car. (None of the 24 cars was equipped with constant-contact type bearings.) Additionally, 1 of the 24 cars had a cracked side bearing top plate, 4 cars had loose side bearing top plates, and 1 car had a 7-inch crack in a body bolster web.

According to NRCC records, 32 of the 36 cars rebuilt at NRCC had side bearing repairs made during the rebuilding process. These repairs consisted mainly of roller renewal, roller housing repair, and the addition of shims to the trucks or car bodies.

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[36] Rule 60(B)(2) of the AAR's Field Manual of the Interchange Rules requires the body center plate to be secured with high tensile steel bolts.

During a postaccident inspection of WSOR 501006 at the Wisconsin & Southern Railroad facility in Horicon on April 11, 1989, Safety Board investigators found that the truck sideframes on the A-end of the car did not conform to the requirements of the AAR Manual of Standards and Recommended Practices described in the section "Method of Marking and Mating Cast Steel Truck Side Frames." The recommended standard establishes:

> ...a uniform practice for marking truck side frames to permit pairing of frames on the same truck, with respect to dimensions between centers of journal boxes (wheelbase)....Under the adopted system, the number of buttons remaining on the side frame indicates the variation over the nominal dimension, by tabulation, and frames having the same number of buttons or within one of the same number are selected for use on the same truck. By following this method, the variation in wheelbase dimension would not exceed .150 inch.

The A-end left truck sideframe had four buttons, and the A-end right truck side frame had two buttons.

Shop Inspection Program of the AAR.--Rule 120 of the Field Manual of the AAR Interchange Rules authorizes the AAR's Mechanical Inspection Department (MID) to conduct inspections and investigations to check compliance with the Interchange Rules and the mandatory provisions of the AAR's Manual of Standards and Recommended Practices. MID inspectors are permitted to inspect freight car component repair and reclamation facilities and to analyze car repair records to detect uncommon trends in the repair of cars and to identify problems with specific components, rules, or billing charges. The rule authorizes the inspection of signatories to the Interchange Rules; railroads and private car companies not signatories to the rules; contract shops engaged in building, rebuilding, repairing, or demolishing cars; and plants engaged in the manufacture, repair, and reclamation of material.

Section D of Rule 120 authorizes a $750 charge for certification of a nonmember's facility to defray the expenses of an inspection, and the rule states that if a certified shop is temporarily shut down for more than 12 months, the certification will be withdrawn. AAR representatives stated, however, that the AAR neither certifies nor approves contract repair shops. Instead, the referenced certifications are for wheel shops; roller bearing reconditioning shops; and air brake, coupler, and draft gear reconditioning facilities because of the precise work required at those facilities. The AAR has not believed it necessary to certify freight car repair ("rip track") shops.

According to AAR personnel, although a contract freight car repair shop is not required by the AAR to seek an inspection of its facility by an MID inspector, railroads providing service to a contract repair shop ask the facility, as a practice, to obtain an MID inspection as an assurance that the shop is providing an acceptable quality of work. During a routine inspection of a contract repair shop, an MID inspector determines if proper equipment and manuals are available to do repair work offered, if repairs are made according to interchange rules and standards, and if there is an adequate recordkeeping system. Additionally, MID inspectors examine one or more

repaired cars leaving the shop, if available, to determine if the cars meet all mechanical requirements and if any defects have been overlooked.

The owner of the NRCC contract car repair shop testified that it was his understanding that the AAR certified rebuild shops, or the rip track portion of the shop, after an inspection of the facility. He said he believed the inspections were necessary because private car owners and railroads considering use of the facility want to know if the shop is AAR-approved.

A routine inspection of the NRCC contract car repair shop was conducted by an AAR MID inspector on January 14-15, 1987. The MID inspector noted the following problems: (a) operative roller bearing grease gun not available; (b) AAR M-963 journal box lubricating oil not available; (c) center plate lube not available; and (d) steeple back journal bearing wedge condemning gauge not available. No repaired cars leaving the shop were inspected because none were available at that time.

An officer of the repair shop was present during the inspection and was provided a copy of the inspection report. In a letter dated February 6, 1987, to the president of the repair shop, the AAR asked that exceptions be corrected because they were serious and asked to be advised when the corrections were made. A copy of the inspector's report was sent to the railroad that provided service to the repair shop, in accordance with normal procedures, to alert the railroad of deficiencies found. A railroad may then adjust the level of inspection activities as necessary to determine the mechanical condition of cars the railroad would pick up at the shop. The AAR had no records to confirm that the exceptions were corrected, and no followup routine inspection was performed as of June 1989.

The AAR stated that although they desire to conduct followup routine inspections of car repair shops every 12 to 18 months, limited staff resources and an increasing number of car repair shops do not permit followup inspections within that time. The AAR has 10 MID inspectors qualified to conduct routine inspections--including 4 wheel shop inspectors--and about 2,000 shops that require inspection. Of the 2,000 shops, the AAR estimates that 800 shops are contract car repair shops and that 200 are reconditioning facilities for wheels, axles, and other freight car components. The remaining 1,000 are primarily railroad (carrier)-operated shops.

The FRA has no regulations governing the operation of freight car repair shops, and therefore does not inspect such shops. Rather, the FRA requires that all freight cars meet or exceed minimum FRA safety regulations when transported.

Car Rebuild Program of the AAR.--Freight cars rebuilt in accordance with AAR procedures are given new "rebuilt" birthdays, and they are assigned higher book values that reflect expenses paid by the car owners to improve the cars. To qualify for AAR rebuilt freight car status, cars must be rebuilt to all current AAR Interchange Rules and FRA safety regulations, must be returned to the same type service (for example, a hopper car must remain a hopper car), and must be more than 10 years old but less than 25 years old; appropriate paperwork must also be completed and approved by the AAR.

After purchasing the 36 20-year-old hopper cars, Northern Rail Car Leasing notified the AAR by telephone of its intent to rebuild the hopper cars and then sent the required forms and fees to the AAR to begin the qualification process. On July 18, 1988, the Northern Rail Car Corporation notified the AAR that a sample (representative) rebuilt car was available for inspection. The AAR's procedures require that one or more rebuilt cars in a project be inspected by an MID inspector to determine if the car(s) meet all current AAR Interchange Rules and FRA safety regulations.

On July 19, 1988, an MID inspector arrived at the NRCC facility and inspected one of the rebuilt cars from the project, car WSOR 501032. He completed an inspection form, noting that the car met all requirements except being weighed. The inspector told NRCC personnel to rebuild the remaining cars in the same manner. The MID inspector later said that he inspected only one rebuilt car because it was the only one of the 36 available. The owner of the facility said, however, that he believes five rebuilt cars were available because the cars were numbered as they were completed, from the highest number to the lowest, and therefore cars WSOR 501036, WSOR 501035, WSOR 501034, and WSOR 501033 should have also been finished.

On September 26, 1988, the AAR notified the NRCC by letter that WSOR 501032, inspected on July 19, 1988, met all mechanical requirements and had been approved by the AAR's Mechanical Division, and that approval forms had been forwarded to the AAR's Transportation Division for approval and handling. The AAR letter also requested another form from NRCC, listing costs associated with rebuilding the cars, so that official rebuild status and new car values could be assigned. The NRCC submitted the additional form to the AAR on December 6, 1988. At the time of the Akron accident, the AAR had not yet approved official rebuild status of the hopper cars.

On November 21, 1988, another MID inspector, while inspecting cars for proper cargo loading at a railroad yard in Chicago, Illinois, inspected WSOR 501017, one of the 36 rebuilt cars. He noted that the car was marked with a recent rebuilt date. He saw that the car did not comply with AAR rules because it was equipped with threaded fittings in the air brake line (Rule 4(B)(2) of the Field Manual of the AAR Interchange Rules) and that it did not comply with the FRA safety regulations (49 CFR Part 231, Railroad Safety Appliance Standards) because it was equipped with side ladders extending from the bottom to the top of the car. Because all 36 rebuilt cars were equipped in a similar manner, a telephone agreement was reached between the Wisconsin & Southern Railroad and the AAR requiring the Wisconsin & Southern Railroad to correct these deficiencies as the cars returned to the railroad's terminal in Horicon. During the Safety Board's visit to the Wisconsin & Southern facility at Horicon on April 11, 1989, Safety Board investigators determined that as of April 11, 1989, these deficiencies had been corrected on 25 of the 36 cars. According to the owner of the Wisconsin & Southern Railroad, all 36 cars were repaired by about May 26, 1989.

Shop Procedures of Northern Rail Car Corporation After the Derailment.--A Northern Rail Car Corporation repair shop manager, who was a car repairman at the time of the WSOR hopper car rebuild project, said that quality control procedures had been improved since the Akron derailment. He stated that a

quality control inspection sheet was now used in conjunction with the repair of all cars. Among other requirements, the following items must now be checked before repaired cars are approved by the NRCC supervisors: (a) the measurement of gib clearances; (b) the measurement of side bearing clearances; and (c) the proper match of buttons on sideframes.

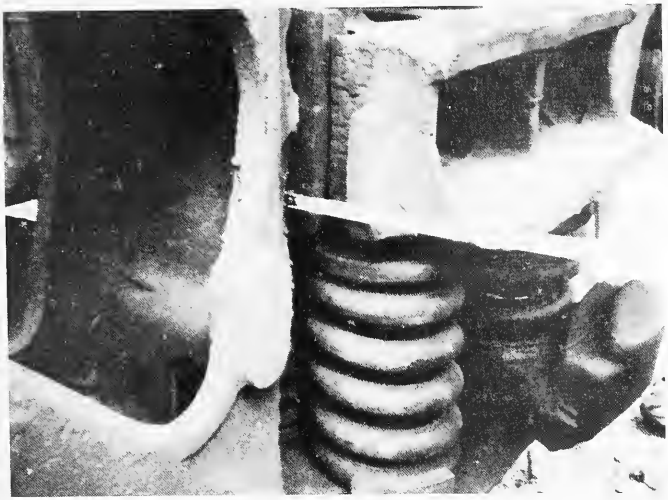
He also stated that more frequent inspections are made by supervisors while cars are being repaired and that two supervisors must inspect finished cars, using a checklist, to be certain that all repairs had been performed properly and that needed repairs were not missed.

The NRCC shop manager told the Safety Board that excessive gib clearance would result in lateral banging on a truck [sideframes]; that when inspecting car WSOR 501003 after the accident, he recognized that the truck bolster on the B-end of the car was the wrong size; and that the truck bolster had been installed at the NRCC repair shop. The shop manager also stated that excessive side bearing clearances would permit a car to experience greater harmonic action (rocking of the car side to side as it travels down a track), and that insufficient side bearing clearances would bind the side bearing rollers and therefore bind the truck (restrict the ability of a truck to swivel and therefore restrict the truck's ability to follow the contour of a track). The shop manager stated that before the accident, gib clearances were not routinely measured after repair work and that only a few car repairmen had gauges for measuring side bearing clearances. Since the accident and the implementation of a quality control program, he said that gib and side bearing clearances must be measured and each car repairman now had a proper measuring gauge.

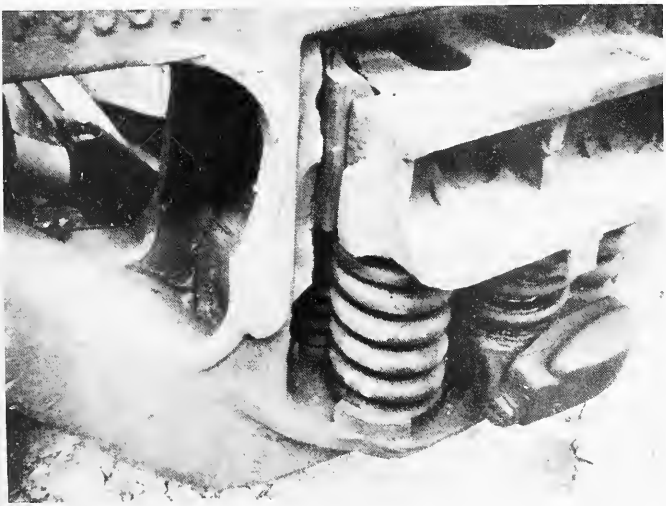
The shop manager said that new employees are trained by pairing them with experienced employees in a team concept, and that AAR manuals are used to identify wear tolerances and replacement requirements. When questions about replacement components cannot be confirmed by the AAR manuals, shop managers call the AAR or car component manufacturers for assistance.

Other Car Repair Information.--Following the postaccident detection of the mismatched truck bolster on WSOR 501003, the owner of the Wisconsin & Southern Railroad told his car inspectors to look closely for mismatched bolsters on other cars. On May 10, 1989, Wisconsin & Southern Railroad car inspectors found a freight car with excessive gib clearances. This car, CNW 69883, was loaded with sugar and offered at interchange by the Chicago and North Western Transportation Company. The sideframes at both the A- and B-ends had been damaged as a result of contact with the truck bolster (figure 17).

The Safety Board sought historical car repair records to determine if the car had been previously derailed and if it was equipped with a correct bolster. No records of a previous derailment were found and no records to indicate a mismatched bolster were found. Wisconsin & Southern Railroad repair records indicate that identical type bolsters were replaced at the time of repair, May 25, 1989.



A-END



B-END

Figure 17.--Damage to the sideframes of car CNW 69883.

Freight Car and Train Inspection Information

Freight Car Inspections.--The FRA requires predeparture inspections of freight cars in 49 CFR Part 215.13: "At each location where a freight car is placed in a train, the freight car shall be inspected before the train departs. This inspection may be made before or after the car is placed in the train." The regulation also states that if a designated inspector (designated by the railroad), defined in Section 215.11, is on duty for the purpose of inspecting at a location where the inspection is required, the designated inspector must determine whether the car is in compliance with the Federal safety regulations. Normally, a designated inspector is available at a railroad yard or interchange point.

However, at a location where a designated inspector is not on duty (for example, at an industrial site where a traincrew picks up a freight car), the freight car must be inspected, at a minimum, for imminently hazardous conditions considered likely to cause an accident or casualty before the train arrives at its destination. Items that must be inspected if a designated inspector is not available are specifically defined in the regulations:

(1) Car body lean: (a) leaning or listing to side, (b) sagging downward, (c) positioned improperly on truck, (d) object dragging below, (e) object extending from side, (f) door securely attached, (g) broken or missing safety appliance, (h) lading leaking from a placarded hazardous material car;
(2) Insecure coupling;
(3) Overheated wheel or journal;
(4) Broken or extensively cracked wheel;
(5) Brake that fails to release; and,
(6) Any other apparent safety hazard likely to cause an accident or casualty before the train arrives at its destination.

The FRA considers hazardous conditions associated with this inspection to be readily discoverable by a traincrew.[37]

The FRA requires designated inspectors to be qualified to inspect railroad freight cars for compliance and to have demonstrated to the railroad a knowledge and ability to inspect railroad freight cars.[38] The FRA has not provided a standard to measure demonstrated knowledge and ability for designated inspectors (usually carmen) or train crewmembers; the FRA allows carriers to set their own standards. The FRA expects the inspection to be sufficient to assure that freight cars, including side bearing clearances, are in compliance with Federal regulations before they are transported. The

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[37] The brakeman on train D812-26 performed this inspection on the five cars added to the train in Warwick; he found no imminently hazardous condition.

[38] Title 49 CFR 215.11, Designated Inspectors.

FRA regulations do not address gib clearances between truck bolsters and sideframes.

Designated inspectors also inspect freight cars for compliance with safety standards in the Field Manual of the AAR Interchange Rules adopted by the Association of American Railroads. Among other items, designated inspectors (carmen) look for broken, damaged, and noncomplying components on the freight car. Items to be inspected include side bearing clearances and broken or excessively worn truck components. Although carmen look for improper or mismatched parts, mechanical supervisors for CSX said that during a normal predeparture freight car inspection or interchange inspection, it is unlikely that a carman would identify excessive gib clearance resulting from a mismatched truck bolster and sideframes. Rather, CSX supervisors said carmen performing these inspections would be expected to identify excessive gib clearances resulting from damaged or excessively worn parts.

Inspections of Car WSOR 501003.--On October 30, 1988, the Chicago and North Western Transportation Company (CNW) first accepted WSOR 501003 from the NRCC repair shop after it was rebuilt. This was the first opportunity for a railroad to inspect the car and to identify excessive gib clearances or improper side bearing clearances before the car entered the transportation system. The car was accepted by the CNW, interchanged with the Wisconsin Central Railroad Company, and then interchanged with the Wisconsin & Southern Railroad Company.

WSOR 501003 was then filled with sand and offered for transportation with its first load since the rebuild. The full car was picked up by the Wisconsin & Southern Railroad, interchanged with the Wisconsin Central Railroad, and then interchanged with the CSX Railroad, which delivered the full car in Akron. The car was emptied and returned over the same route, completing its first round trip between November 18 and December 14, 1988. The car was filled with sand and completed a second round trip over the same route between January 16 and February 5, 1989. WSOR 501003 was on the first half of its third round trip when the Akron derailment occurred.

Car WSOR 501003 had been interchanged between railroads at least 12 times, and 4 separate railroads had been involved with the movement of the car between the time it was rebuilt and the time of the Akron derailment. The car was subject to several FRA-required predeparture freight car inspections during this period; no exceptions were taken to excessive gib clearances.

The last carman to inspect WSOR 501003 conducted a predeparture inspection of the car in Willard, Ohio, between 2:45 p.m. and 3:45 p.m. on February 26, 1989, before it left for Akron. The CSX carman indicated that he checked about half of the 60 cars in the train and found no cars to be in bad order.[39] He said that when conducting predeparture freight car inspections, he looks for defects involving safety appliances, wheels, springs (missing), wear and tear on castings, brake beams, air brake linkage,

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[39] A second carman checked the remaining cars.

air hoses, and air brake setup. He looks at side bearing clearance and roller bearing condition if he notices a car leaning, and also checks stenciling on the car to determine when a car was last lubricated and when the brakes were last serviced. In his 10 years' work experience, he had never issued a bad order on a car because of excessive gib clearance or defective side bearing clearance. He does not measure gib clearances during predeparture inspections and would not look for that type of problem unless his attention was directed to the matter, such as in a CSX notice. He carried a wheel gauge, a tape measure, wrench, and small pinbar during the car inspections but carried no other gauges. The carman also stated that he was issued a current copy of the AAR field manual, but that he does not carry it with him while inspecting cars; instead, he keeps it in a nearby shelter.

After this accident, the CSX Detroit division managers completed refresher courses on freight car and train inspections, and they reviewed inspection requirements and procedures for all involved mechanical and transportation personnel on the division. Additionally, CSX mechanical department officers conducted unannounced audits at rail yards throughout the CSX system and found that at some locations side bearing inspections were inadequate and that gib clearances were checked only for wear and damage. As a result, mechanical department officers at CSX headquarters sent letters to division-level supervisors systemwide instructing them to reemphasize procedures for side bearing clearance inspections with carmen and to provide increased training to carmen at locations where inadequate side bearing inspections were found. Additionally, the mechanical department acknowledged that gib clearance inspections at rail yards must go beyond inspecting for wear and damage, and instructed its division supervisors to increase carmen's awareness of the need to check gib clearances as part of the overall truck integrity assessment program. CSX intends to accomplish improved inspections of gib clearances by reemphasizing to carmen the AAR Interchange Rules that set gib clearance requirements.

Tests of Train Air Brakes.--The FRA requires train air brake tests at the initial and intermediate terminals to determine that the brakes are operating properly.[40] In accordance with the regulations, each train must be inspected and tested where a train is originally made up and after one or more cars are added to the train. The regulations require that brake pipe leakage must not exceed specified limits, and brakes must apply and release as required. When a carman or qualified person performs the test at the initial terminal, the person participating in the test or a qualified person who had knowledge that the test was made must notify the engineer that the initial terminal road train air brake test was satisfactorily performed. According to the FRA regulations, this notification must be made in writing if the traincrew reports for duty after the qualified person goes off duty.

An initial terminal air brake test was performed on train D812-26 by carmen at the Willard yard, and that information was provided verbally to the traincrew.

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[40] Title 49 CFR Parts 232.12 and 232.13.

The brakeman stated that after he inspected the five cars picked up in Warwick, air was applied to the five cars and he observed that the air brakes on all five cars released. The cars were then moved and set aside while other cars were dropped off. The brakeman said that afterward, the locomotives and four front cars were reattached to the five cars. The brake system was charged and he observed the brakes set and then release on the last car, indicating that they functioned properly. The brakeman estimated that it took 7 to 8 minutes to perform the air brake test.

Track Information

Track.--The derailment occurred 232 feet south of MP 16 on the northbound main track of the Akron Branch Line, which extended in a geographically north/south direction for 27.1 miles between Warwick and Hudson, Ohio. The Akron subdivision consisted of 11.6 miles of single main track, which was owned by Conrail and maintained by Conrail's Pittsburgh division, and 15.6 miles of double main track owned jointly by Conrail and CSX. Conrail owned the northbound track, on which the accident occurred, and CSX owned the southbound track. Under a joint facility agreement, all tracks were maintained by Conrail and jointly used by both railroads. Conrail operated one train per day over the tracks, and CSX operated about 20 trains per day over the tracks. At the time of the accident, CSX and Conrail were negotiating for the sale of the Akron Branch Line to CSX; however, the proposed sale had not been filed with the Interstate Commerce Commission. On February 5, 1990, the sale of the Conrail-owned portion of the Akron Branch Line was finalized and ownership was transferred to CSX.

In accordance with the joint facility agreement, CSX paid Conrail for using the track on a car-mile basis. Those funds collected by Conrail were not dedicated to maintenance expenses on the Akron Branch Line; instead, the funds were placed in a corporate account and track maintenance expenses were allocated on a total system priority basis, a standard industry practice.

In the direction of train movement, the northbound track was on the east side (right) of the southbound track. Running parallel to the northbound track, on the east side, was an auxiliary track that provided access to Conrail's South Akron yard. The South Akron yard consisted of 17 tracks located north (direction of train travel) of the accident site between MP 16 and MP 15. The auxiliary track was about 10 inches lower (in elevation) than the northbound track.

Starting about 1.2 miles south of the derailment site (MP 17.1), the track grade made a transition from a 0.56-percent ascending grade to a 0.09-percent ascending grade, and then to a 0.73-descending grade in the last 3,893 feet leading into the point of derailment. The derailment site was at the bottom of a vertical curve where the track made a transition to a 0.65-percent ascending grade.

In the same 1.2-mile area, the track curved 2 degrees 5 minutes to the left for 1,337 feet and then turned tangent for 1,034 feet. It then curved left through a 2 degree 16 minute compound curve for 1,815 feet, becoming tangent for 729 feet. The track then curved right through a 1 degree

30 minute curve for 1,349 feet to the point of initial derailment, and about 185 feet beyond that point. Prescribed superelevation was 1/2 inch with 31-foot spirals on each end of the curve.

Two turnouts were located at the extreme north end of the curve (figure 18). One was a trailing point turnout in a crossover connecting northbound track No. 1 to southbound track No. 2; the other was a facing point turnout connecting northbound track No. 1 to the auxiliary track on the east side of the main tracks. A Conrail assistant division engineer for track stated that although it is not a good operating practice to install turnouts in a Class 3 track curve (the track designation at this location), it is a common [industry] practice.

The northbound track in the area of derailment was constructed of 132-pound continuous welded rail that was laid new in 1978. The rails rested on double-shouldered tie plates and 8 1/2-foot wooden crossties. The rail was restrained by two rail-holding spikes and two plate-holding spikes per tie plate. In general, every other tie was box-anchored to control longitudinal rail movement, with some anchors intermittently missing. Anchors were applied to every tie for about 200 feet approaching and leaving the turnouts. Only 1/2 inch of longitudinal rail movement was measured at the derailment site.

Track surface and alignment was maintained on crushed rock ballast. At several locations, mud had permeated the ballast section. Muddy track conditions of this type were evident in the two main track turnouts (figure 19A) and on a bridge about 403 feet south of the point of initial derailment (figure 19B). A slow order for 25 mph was in effect at MP 24.8 on northbound track No. 1 (8 miles from the accident site) at the time of the accident as a result of defects in the rail surface profile caused by mud.

Both turnouts on the northbound main track were constructed with 132-pound No. 10 bolted rigid frogs and were 23 feet long. The trailing point turnout was equipped with standard, reinforced, 20-foot switch points, with the main track closure rail bolted in place with 36-inch joint bars. The facing point turnout, however, was equipped with 27-foot switch points, with the main track closure rail welded to the heel of the switch point and the toe of the frog. The bent stock rail was undercut to accommodate the Samson main track (straight) switch point.

Description of Physical Evidence.--A postaccident inspection of the track approaching the point of derailment revealed discrepancies in the curve alignment and the track surface. The uniform alignment of the 1 degree 30 minute curve was interrupted by segments of irregular alignment caused by the presence of two turnouts located in the body of the curve. Throughout the curve, the high rail was curve-worn. However, at the toe of the trailing point frog, the rail wear tapered onto the closure rail for 14 feet, where it gradually tapered to no curve wear. Twelve feet north of the point where the high rail wear ended, wear was visible on the low rail for about 17 feet.

Figure 18.--View of tracks at accident site facing south. Arrows identify the following: (1) northbound track, (2) southbound track, (3) auxiliary track, (4) first turnout (direction of train movement), and (5) second turnout and area of point of derailment.

Figure 19.--Muddy track conditions on the northbound track: (A) at the turnouts, and (B) at the bridge south of the derailment site.

Segments of irregular alignment were also present in the facing point switch in the area of the switch, the closure rail, the frog, and behind the frog.

Track surface through both turnouts was about 1/2 inch to 1 1/4 inch above the designated elevation; these differences were in compliance with Federal track standards.

The first indication of a derailment was a flange mark on the base of the rail 47 feet behind the point-of-switch, in the facing point turnout (figure 20). This mark was on the right (field side) of the low (east) rail and was accompanied by a similar mark on the right (gauge side) of the high (west) rail. In the direction of train movement, the wheels derailed to the right side. There were only two marks representing one derailed axle. The marks progressed through the turnout and astraddle the frog; there were no marks on the guard rail. Marks indicated that a derailed wheel on the right (turnout) side struck the joint bars at the heel of the frog and climbed over the turnout rail. Immediately north of the frog, two distinct marks were visible in the center of the track between rails: one about 13 inches from the high rail and about 2 inches wide; the other about 25 inches from the high rail and about 3 inches wide. Only one mark was visible on the east side of the low rail near the end of the ties. The marks progressed 40 feet north of the frog to the point where total track damage occurred.

The facing point switch was found in good adjustment and properly fitted to the undercut stock rail. Rail braces were tight and track gauge at the point of switch was 56 7/8 inches.[41] The switch rods were not bent, nor were there any marks on the Samson switch point.

An abrasion was found on the receiving end of the guard rail in the trailing point turnout. The abrasion was on the guard face wing, about 1 1/2 inches beyond the area of normal contact between the back side of the car wheels and the guard rail. The abrasion was oxidized with a brightly colored rust, consistent with recent origin. The source of the abrasion could not be determined. Additionally, rail corrugation, caused by wheel forces, was found near the bridge immediately south of the accident site (see figure 19B).

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[41] According to 49 CFR 213.53, track gauge must be maintained between 56 inches and 57 3/4 inches.

Figure 20.--Flange mark on base of rail.

Track Inspections.--The Akron subdivision was designated by Conrail as a Class 3 track and was therefore required to meet Federal track safety standards for that class.[42] These standards required the carrier to inspect the track twice weekly, with at least one calendar day interval between inspections. In the 30-day period prior to the derailment, the Conrail track inspector inspected the subdivision in its entirety eight times. During these inspections, nine FRA defects (items that were not in compliance with FRA track standards) were found on northbound track No. 1: one broken joint bar, five joints with sheared bolts, and three joints with inadequate bolts. Other track defects were noted that were not in violation of Federal track safety standards.

A track geometry car last evaluated the territory on December 13, 1988. Three FRA defects were detected within 1 mile south of the derailment site: irregular crosslevel at MP 16.2, MP 16.6, and MP 16.8.

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[42] According to 49 CFR 213.9, the maximum allowable operating speed for a freight train is 40 mph for a Class 3 track, 25 mph for a Class 2 track, and 10 mph for a Class 1 track. If a segment of track does not meet all of the requirements for its intended class, it is reclassified to the next lowest class of track for which it does meet all of the requirements. In such an instance, a railroad may issue a slow order until conditions are corrected.

The Akron subdivision was last inspected by an FRA track inspector for compliance with Federal track safety standards on January 30, 1989. Several inches of snow covered the ground at the time of the inspection. During the inspection, one rail brace defect and nine track bolt defects were detected on northbound track No. 1. Two of the bolt defects were in the immediate area of the derailment and records indicate that repairs were made prior to the accident.

After the accident, between March 1 and 3, 1989, State and FRA track inspectors identified 75 track defects on northbound track No. 1 between MP 11.8 and MP 27.2: 30 track bolt defects, 29 locations of fouled ballast,[43] 4 tie defects, 4 track gauge defects, 5 defective joint bars, 2 irregular crosslevel defects, and 1 switch point stop defect. Some of the defects near the accident site included the following:

> Fouled ballast from MP 16.4 to 16.7 causing track profile to deteriorate;
>
> Crossties not effectively distributed to support a 39-foot segment of train over bridge 16;
>
> Fouled ballast at north end of bridge 16 causing track profile to deteriorate;
>
> Fouled ballast at MP 15.8 causing track profile to deteriorate (about 100 feet); and
>
> Fouled ballast at MP 15.2.

According to the regional track engineer of FRA's Region 2, in which the Akron subdivision is located, the track was not in compliance with Class 3 requirements, based on the finding of 137 defects on the northbound and southbound tracks between MP 11.6 and MP 27.2. He stated that because of 32 joint-bolt defects in which there were fewer than two bolts in each end of a joint, the condition of the track was good only for Class 1. Other items, such as missing or loose frog bolts and fouled ballast, would permit the tracks to be classified as Class 2.

In Ohio, there are two FRA track inspectors and three certified State inspectors who work for the Public Utilities Commission of Ohio. Each inspector is responsible for a distinct territory. The FRA inspector in Cleveland, Ohio, is responsible for inspecting the Akron Branch Line.

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[43] Ballast, the material beneath the ties, may become fouled (contaminated) by different materials, usually dirt or mud percolating up from the subgrade. Fouled ballast, in and of itself, may not constitute an FRA defect unless the condition affects track geometry or tie support conditions.

Track Maintenance.--A three-person Conrail maintenance crew, consisting of one foreman, one truck driver, and one trackman/machine operator, assisted by a welder and helper, was assigned to maintain the Akron subdivision (27 miles). The crew was also responsible for maintaining the frequently used Cleveland Line (31 miles), and the infrequently used Rittman Secondary (11 miles) and Freedom Secondary (33 miles). The efforts of the crew were supplemented by mechanized, extra crew activity, which was allocated annually.

In 1987, $512,000 was allocated and spent on the Akron subdivision northbound track rehabilitation program: 8,136 ties were installed and track was surfaced between MP 18.4 and MP 27.2. In 1988, Conrail track maintenance personnel requested $325,000 for tie renewals and 9 miles of track surfacing between MP 11.6 and MP 18.4 on the northbound track; all funding for this rehabilitation program was denied by Conrail management. The only extra crew activity in 1988 occurred in December: a track surfacing crew spot-tamped the track at selected locations. Track maintenance personnel requested for 1989 $830,000 in the rehabilitation program for track surfacing and tie renewals on northbound track No. 1 between MP 11.7 and MP 27.1. According to Conrail's assistant engineer of track, funding is requested each July for the following calendar year; the requested 1989 funding had not been approved at the time of the accident or by July 1989 at the time of the Safety Board's public hearing.

Training and Emergency Preparedness

Training of Railroad Personnel.--The traincrew had not been provided emergency response training outside of routine CSX operating rules classes. The classes instruct employees on their responsibilities in the event of an accident involving hazardous materials. This training includes a 45-minute video tape on the proper handling of hazardous materials.

Operating Rule 74 requires the conductor or other CSX personnel at an accident site involving hazardous materials to initiate actions necessary to ensure the public safety, and to protect property and the company's interest. In part, the rule requires employees to take the following actions as soon as possible and if it is safe to do so:

(a) Rescue the injured, remove them to a safe area, administer first aid, and call for assistance;

(b) Survey the scene and adjacent area, assess the situation, ascertain the conditions, including identifying cars/trailers containing hazardous materials involved in the emergency or in the immediate area, and notify the proper authority by the quickest means available;

(c) Protect life and property. This may require evacuation of people from the area; fire fighting; removal of cars or containers and their contents; and

(d) In the event that the emergency involves spillage, loss of hazardous materials or fire, the conductor or his designee must notify or request the chief dispatcher to notify the nearest EMERGENCY RESPONSE GROUP, such as the fire and police departments and medical rescue, among others. The conductor or his designee must remain at the scene until the arrival of the Emergency Response Group or until released by the proper authority.

Operating Rule 74-A provides evacuation guidelines to the traincrew, and Rule 74-C requires the conductor to take the initiative to identify himself to the emergency response persons when they arrive at the scene. The rule also requires the conductor to furnish emergency response persons with information obtained from the waybills and the train consist concerning hazardous materials in the train and to provide his knowledge of the current conditions. Operating Rule 74 cautions employees that information identifying the contents of cars involved in the emergency and exact conditions (whether fire, explosion, fuming or leaking of hazardous materials) is vital in determining the required corrective action. A current copy of these rules must be carried by traincrews while on duty.

The CSX had prepared efficiency tests to determine if traincrew actions were performed in accordance with company operating rules; the efficiency tests include criteria for evaluating train and engine crew performance when accidents occur that involve hazardous materials. The efficiency tests inquire if the conductor identified himself to emergency response persons, furnished waybill and consist information, and provided knowledge of current conditions.

A CSX trainmaster who responded to this accident told Safety Board investigators that he had never performed efficiency tests on train crewmembers regarding their responsibilities and actions taken as a result of a hazardous materials emergency. (The trainmaster said that he believed that this could be done only after an emergency.) Although he said he had not performed a formal efficiency test on the traincrew after this accident, he took no exception to their actions relative to the rules because he believed that the conductor, although separated from the fire chief because of the fire, provided necessary information regarding hazardous materials involved in the derailment to the brakeman who was with the fire chief.

According to a CSX corporate official, since the accident, all CSX Detroit division managers have been provided enhanced training on response to rail transportation emergencies involving hazardous materials. Further, division supervisors are now providing additional instruction and testing to traincrews on the matter. CSX is also considering the production of 5- to 10-minute, specific topic video tapes on hazardous materials rules and emergency response for use in operating rules classes.

Emergency Preparedness.--The Akron Fire Department implemented its hazardous materials operations plan, which served as an onscene checklist for each fire department unit. The plan included guidelines for other emergency response agencies involved in the incident.

The City of Akron and Summit County, in which Akron is located, had an emergency operations plan, adopted in July 1988, and administered by the Summit County Office of Emergency Management. The plan was used to help facilitate the evacuation and provide guidance to first responders and supporting agencies. Additionally, the Akron Police Department had a general order in effect, which described the actions to be taken by its members, relevant to hazardous materials incidents.

The fire department conducted hazardous materials incident drills among its firefighters on an instantaneous order from the hazardous materials chief; the drills had not included participation by the railroads operating within the city. The CSX division manager for hazardous materials, however, had conducted in November 1988, an 18-hour class for the fire department that included hands-on instructions for hazardous materials incidents involved with railroad tank cars. In October 1984, Conrail had provided 16 hours of classroom and hands-on hazardous materials training for the fire department.

In October 1988, the B.F. Goodrich Chemical Company and Conrail held a simulated leak of volatile chemicals inside the plant facility while a Conrail train and crew were onsite. In 1987, the B.F. Goodrich Chemical Company provided tours of their facilities to Conrail's South Akron yard personnel. Additionally, the B.F. Goodrich Chemical Company had provided the fire department with information about hazardous materials used in the facility and had cooperated with the fire department in preparing emergency plans.

In November 1989, after this accident, a cooperative venture between CSX, the fire departments and rescue agencies of Summit County, and the City of Akron resulted in 6 days of comprehensive orientation, training, and field exercises on the handling of hazardous materials incidents in rail transportation including tank car, tank truck, and locomotive emergencies. In addition, a major chemical manufacturer and a hazardous materials emergency response company made presentations to fire department personnel, and CSX officials met with city leaders to assure that a cooperative relationship was fully in place in Akron. The CSX believed the training effort to be successful and plans to conduct similar training programs at other locations on its system.

CSX is currently developing a computerized hazardous materials data program that will be able to provide pertinent historical information about hazardous materials movements to local emergency planning committees and agencies in communities through which CSX travels. Additionally, the CSX and the railroad industry are researching methods of providing aboard each train real-time documentation of train consists.

Meteorological Information

On February 23, 1989, conditions at Akron included light snow showers and temperatures between 10 ^{o}F and 19 ^{o}F. On February 24, the maximum temperature was 23 ^{o}F and the minimum was 5 ^{o}F; there was no precipitation. On February 25, the maximum temperature was 38 ^{o}F and minimum was 8 ^{o}F; there

was no precipitation, and skies in the Akron area changed from clear to overcast throughout the day.

On February 26, the skies over Akron were overcast throughout the day with light snow. Total snow accumulation was 2.3 inches (water equivalent of 0.2 inch). The maximum temperature was 34 °F and the minimum was 26 °F.

During the following 4 days, temperatures varied between 14 °F and 36 °F and only a trace of snow was recorded. On March 3, the temperature increased to 52 °F and overcast skies changed to partly cloudy.

Toxicological Information

All four crewmembers were tested for drugs and alcohol at the Akron City Hospital between 12:04 a.m. and 12:31 a.m., February 27, 1989. Blood and urine samples were obtained and sent to the Center for Human Toxicology, University of Utah, Salt Lake City, Utah. All samples tested negative for drugs and alcohol.

Tests and Research

Event Recorders.--Event recorder data packs were removed from CSX units 6124, 6675, 6850, and 6038--the locomotives for train D812-26--and were sent to the Safety Board in Washington, D.C., for readout and evaluation. The data packs came from three-event recorders, which record elapsed time and wheel revolutions for generating unit speed and distance traveled over elapsed time.

Strip charts were generated to show train movement, time, distance, and speed. The following information was produced:

The maximum speed attained by unit 6124 just prior to rapid deceleration was 43.8 mph (with an error tolerance of ±0.1 mph);

The train traveled about 1,195 feet during deceleration; and

After the train stopped following the rapid deceleration, unit 6124 remained stopped for about 8 minutes 35 seconds, and then traveled a distance ranging between 394.6 and 427.4 feet during a period of about 56 seconds.

The Rail Safety Improvement Act of 1988 mandates rules requiring event recorders. The FRA does not require the use of event recorders.

Tests of Locomotives.--CSX locomotives 6124, 6038, 6850, and 6675 were inspected and tested on March 4, 1989, by CSX, FRA, and Safety Board personnel at the CSX mechanical shops in Cumberland, Maryland. Each unit was tested or checked to (1) calibrate the speed recorder, and (2) calibrate the speed indicator. All speed recorders and speed indicators were within the FRA requirement of ±3 mph for speeds of 30 mph or less and ±5 mph for speeds above 30 mph. At 40 mph, the speed indicator on unit 6124 displayed 39 mph while the speed recorder recorded 40 mph.

The power brake interlock was checked on the four locomotives from the lead locomotive 6124. Unit 6124 was a GP40-2 built in 1975. The remaining three locomotives were older GP40 units. Unit 6124 had a unique trainline emergency feature designed to give an engineer 18 seconds in which to release (bail off) his independent or locomotive brakes and still apply power in an effort to pull or break away from the rest of the train and to prevent any cars from piling into the locomotives and crew. After 18 seconds, the engine drops to idle and the power cannot be reinitiated by throttle modulation until the power control relay is reset, which requires a 90-second delay after the trainline air is recovered to the original feed valve setting on the control locomotive.

The test verified that the power control relay functioned as designed and did not actuate the power brake interlock for 18 seconds after an emergency brake application occurred, such as a trainline separation or excessive leakage.

Land-Use Information

The City of Akron does not restrict the use of land adjacent to mainline railroad tracks through minimum setback requirements (buffer zones) or by prohibiting the permanent or temporary storage of hazardous materials adjacent to mainline tracks.

The CSX, however, does impose some restrictions on the use of land it controls adjacent to mainline tracks. On land it owns and leases to others, the CSX prohibits the storage of liquefied petroleum gas in permanent tanks, with a capacity exceeding 12,000 gallons, within 200 feet of mainline tracks unless special permission is granted. Additionally, the CSX restricts the permanent storage of flammable and combustible liquids near its mainline tracks. For example, storage tanks with a capacity between 18,000 and 50,000 gallons must be set back 75 feet from mainline tracks, and storage tanks exceeding 250,000 gallons capacity must be set back 200 feet.

An Interindustry Rail Safety Task Force established by the Chemical Manufacturers Association (CMA) and the AAR, and consisting of senior managers representing the chemical, and railroad and tank car manufacturing industries recently made several recommendations to the chemical and railroad industries, which have been adopted by the CMA and the AAR. In conjunction with those recommendations and on January 4, 1990, the AAR issued Circular No. OT-55, "Recommended Railroad Operating Practices for the Transportation of Hazardous Materials." In part, Circular No. OT-55 establishes proposed separation distances for loaded tank cars and storage tanks from mainline Class 2 track or better. The recommended separation distances, which apply to storage on railroad property and on chemical company property located close to railroad mainline tracks, are as follows:

Activity	Combustible Liquid, Corrosive Material and ORMs[44] (feet)	Poison Inhalation Hazard (Packing Group I) and All Other Hazard Classes (feet)
Loading or unloading:		
(a) If conditions permit	50	100
(b) Minimum distance	25	50
Storage of loaded tank cars	25	50
Storage in tanks (permanent)		
(a) If conditions permit	50	100
(b) Minimum distance	25	50

The recommendation on separation distances states that "with regard to existing facilities maximum reasonable effort should be made to conform to this standard taking into consideration cost, physical and legal constraints."

The recommended separation distances were made, in part, after members of the task force made graphs from Safety Board accident data on the maximum distance equipment traveled from track center in accidents. The group's analysis of the graphs showed that in about 50 percent of the railroad accidents in the Safety Board data base, equipment traveled more than 40 feet from the track; in about 2 percent of the accidents, equipment traveled more than 100 feet from track center. However, the task force was advised by its members to interpret the results with caution because (1) the accidents selected for analysis were not a random, independent sample of all train accidents but were believed to be more serious than average, and (2) the analysis does not control for steep embankments adjacent to track that might cause equipment to travel farther.

Other information considered by the task force included (1) a series of recommendations made by the Safety Board to the AAR on April 28, 1982, that addressed the vulnerability of hazardous materials stored near tracks,[45] and (2) consistency with nationally recognized safety standards. Standards considered by the task force included the American National Standards Institute K-61.1-1989 for anhydrous ammonia; National Fire Protection Association (NFPA) No. 30, "Flammable and Combustible Liquids Code"; and NFPA Standard No. 58, "Storage and Handling Liquefied Petroleum Gases."

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[44] DOT hazard classification for other regulated materials (ORM).

[45] Safety Recommendations I-82-1 through -7 issued April 28, 1982, are addressed in the analysis of this report.

ANALYSIS

General

The four crewmembers of train D812-26 were qualified for their positions by CSX. Postaccident tests of the airbrakes indicate that they were functioning properly and were, therefore, not a factor in this accident. Drugs and alcohol were not factors in this accident. Weather also was not a factor in the accident.

The Derailment

The physical evidence indicates that the point of derailment occurred near the switch in the facing point turnout on the northbound mainline track. Postaccident inspection of the cars involved in the derailment revealed that only one car exhibited the heavy rail burn marks (which were the result of the derailment) seen on the left sideframe of the B-end truck of car WSOR 501003. Because this physical evidence strongly suggested that WSOR 501003, the 13th car in the train behind the locomotives, was the first car to derail, the investigation examined various factors that could have led to the derailment of this car including the mechanical condition of WSOR 501003, the operation of the train as it approached the derailment site, and the track conditions in the derailment area.

The postaccident inspection of WSOR 501003 revealed (1) that the truck bolster on the A-end of the car was different from the truck bolster on the B-end, (2) that the gib clearance between the bolster and truck sideframe on the B-end truck was more than 3 inches, exceeding the limits listed in the AAR Interchange Rules, and (3) that the side bearing clearances exceeded the limits listed in the FRA regulations and the AAR Interchange Rules. Because the original equipment was used in reconstructing the cars after the derailment and because there were no broken parts associated with the truck bolsters and sideframes on WSOR 501003, there should have been no variation in the measurements of side bearing clearances and gib clearances taken before or after the accident. Therefore, the Safety Board concludes that the excessive gib clearance on the B-end truck and the out-of-limits side bearing clearances on WSOR 501003 existed before the derailment. There was no evidence of preaccident mechanical deficiencies with the other cars involved in the derailment.

Limits on gib clearances are set to provide the optimum maneuverability of the truck to follow the contour of the rail as the wheels of a car follow the track. Insufficient gib clearance will tend to cause the truck to bind as the rail car enters a curve, whereas excessive gib clearance results in the truck not being guided adequately (too loosely) through the curve. Out-of-limits side bearing clearances can result in the car rocking excessively from side to side, particularly if the car traverses any irregular track conditions.

Postaccident inspection of the track in the derailment area revealed segments of the track in which the higher rail was worn. This is evidence of irregular alignment, probably as a result of the two turnouts located in the curved area of the track. Areas of fouled ballast approaching the point of derailment also existed.

There was no evidence to indicate that the train was being operated any differently than it had been on previous occasions, and, based on the engineer's testimony that the throttle was in the idle position, there would not have been any operationally induced in-train dynamics, such as slack run-in as a result of brake applications. The three-event recorder indicated that the train was probably traveling about 43 mph at the time of derailment, or 3 mph over the maximum allowable speed. As a result of fouled ballast in the area approaching the derailment site, WSOR 501003 may have experienced some rocking motion that would be compounded or exaggerated by the excessive side bearing clearances. The lower the speed of the train, the more time there is available for a car, after traversing an area of fouled ballast, to correct itself or "settle down" before reaching another area of track irregularity. Because the area of fouled ballast near the bridge was more than 400 feet from the point of derailment, there was sufficient time for WSOR 501003 traveling at 43 mph to "settle down" before reaching the turnouts in the curve. However, just before the turnouts, the ballast was again fouled and this may have permitted the car to again begin rocking as it entered the first turnout.

Irregularities in the track surface and alignment affect normal lateral and vertical forces of wheels moving along the rails; on curves, the effects of these irregularities become more pronounced. As car WSOR 501003 entered the curve, vertical wheel loading shifted as a result of a transfer of weight to the wheels on the outside of the curve and, in combination with the irregular track alignment (turnouts in the curve), caused lateral movement of the car (or slapping of the wheels against the rails). Because of the excessive gib clearance on the B-end truck (the lead truck in the car on this trip), the truck was being loosely guided through the curve and the turnout; this action in combination with the lateral and vertical movement of the car, exacerbated by the out-of-limits side bearing clearances, probably caused the lead wheels to derail. The Safety Board concludes, therefore, that the excessive gib clearance on the B-end truck and the out-of-limits side bearing clearances on car WSOR 501003 combined with the fouled ballast and the irregular alignment of the track in the turnouts caused the derailment of train D812-26.

The Safety Board attempted to determine why WSOR 501003 had not derailed during the previous two trips over the same territory. However, the Safety Board could not determine which end of the car was the lead end during the previous trips, the position of the car in the trains during the previous trips, the speed at which the trains were being operated during the previous trips, or the condition of the track during the previous trips--all factors that could have affected the dynamics of the car. The Safety Board, therefore, could not definitively determine why the car did not derail on the previous trips. However, it is likely that all the conditions that existed on February 26, 1989, did not exist during either of the previous trips.

Event Recorders

The event recorders installed on the four CSX locomotive units recorded only elapsed time, locomotive speed, and distance traveled; however, multi-event recorders are readily available that record other parameters including traction motor current, throttle position, locomotive braking, and direction of travel. Had the units been equipped with multi-event recorders, Safety Board investigators would have been able to obtain more information regarding the manner in which the train was being operated approaching the accident site, particularly throttle positions and the timing of brake pipe pressure reductions. Further, without the multi-event recorders, investigators were unable to corroborate crew testimony about certain aspects of how the train was being operated immediately before the derailment.

The Safety Board has documented its position regarding the mandatory use of event recorders in the railroad industry in previous accident investigations[46] and through the issuance of safety recommendations to the industry and the Federal Railroad Administration. Further, the Safety Board has stated in previous reports of accident investigations that the Rail Safety Improvement Act of 1988 mandates rules requiring event recorders and does not give the FRA freedom to decide whether Federal regulatory intervention on this subject is necessary. Consequently, the Safety Board has recommended that the FRA "expedite the rulemaking requiring the use of event recorders in the railroad industry" (Safety Recommendation R-89-50). The FRA's position, as stated on March 30, 1990, in its most recent response to Safety Recommendation R-89-50, is that the FRA is "analyzing...information to determine if a Federal requirement for event recorders is cost beneficial, and if so, how a rule is to be implemented." While the lack of effective action by the FRA continues to cause the Safety Board concern, it should be noted that the FRA administrator has agreed that some type of recording device should be required on trains, and a proposed rule is currently being developed by the FRA. In view of FRA's effort to proceed with rulemaking activity, Safety Recommendation R-89-50 will be classified as "Open--Acceptable Response."

Track Inspections

About 1 month before the accident, the Akron subdivision was inspected by an FRA track inspector to determine compliance with the Federal track safety standards. During this inspection, one rail brace defect and nine track bolt defects were noted on the northbound track. Two days after the accident, the same area was inspected by State and Federal track inspectors,

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[46] (a) National Transportation Safety Board. 1989. Head-on collision between Iowa Interstate Railroad Extra 470 West and Extra 406 East with release of hazardous materials, near Altoona, Iowa, on July 30, 1988. Railroad Accident Report NTSB/RAR-89/04. Washington, DC. 98 p. (b) National Transportation Safety Board. 1990. Derailment of Southern Pacific Transportation Company freight train on May 12, 1989, and subsequent rupture of Calnev petroleum pipeline on May 25, 1989, San Bernardino, California. Railroad Accident Report NTSB/RAR-90/02. Washington, DC. 193 p.

and 75 track defects were noted including 30 track bolt defects and 29 locations of fouled ballast. Certain track defects, such as missing bolts and defective joint bars, are readily determinable to track inspectors, whereas other track conditions, such as fouled ballast, require a more subjective evaluation. The discrepancy in the number of defects noted 1 month before the accident and immediately after the accident is of concern to the Safety Board. Although the track in the immediate area of the derailment may have been in compliance with Class 3 standards, the track in the general area north and south of the accident site was determined by an FRA inspector after the accident to be out of compliance with the Class 3 standards. Although the Safety Board acknowledges that track conditions may deteriorate during a 1-month period, the Safety Board does not believe that conditions deteriorated rapidly enough in that short period to account for the discrepancy in the defects noted after the accident. Several inches of snow covered the ground when the first inspection was conducted, which raises concerns about the adequacy of conducting an inspection under those conditions. The snow cover may explain why many defective track conditions went unnoticed. However, because there is a certain amount of subjectivity in evaluating some track conditions, it is also possible that defective track structure conditions are not being uniformly noted in the Akron subdivision. Whatever the reason for the discrepancy in the track defects noted, the Safety Board is concerned about the quality and thoroughness of the FRA's inspection of the track prior to the accident. Accordingly, the Safety Board believes that the FRA should evaluate the adequacy of track inspections being conducted on the Akron subdivision and institute necessary changes to ensure proper inspections.

Track Maintenance

The results of the investigation suggest that the maintenance program in place for the tracks in the accident area had reached a point of being reactive rather than preventive, possibly because of the pending sale of the northbound track. All funding requested by Conrail track maintenance personnel for 1988 track rehabilitation had been denied. The only extra crew activity occurred in December 1988 when a track surfacing crew spot-tamped the track at selected locations. At the time of the accident, the funding request by maintenance personnel for 1989 track rehabilitation had not yet been approved. The condition of the track in the area after the accident, as documented by track inspectors, and the fact that no funding had been approved for track rehabilitation for more than a year, suggests that the pending sale of the northbound track to CSX may have affected Conrail's decision to not allocate the necessary resources for the rehabilitation. Conrail's decision to delay rehabilitation of the track or not to place a slow order on the track in the accident area contributed to the cause of the accident.

Freight Car Inspections

Car WSOR 501003 had been inspected on several occasions during predeparture inspections, as required by Federal regulations, and when the car had been interchanged between railroads, in accordance with the AAR Interchange Rules. WSOR 501003 had been inspected both at locations where a

designated inspector was and was not on duty. Given that only six items must be inspected for determining imminently hazardous conditions if a designated inspector is not on duty, the Safety Board believes that a train crewmember could not have been expected to detect the excessive gib and out-of-limits side bearing clearances on WSOR 501003.

However, the Safety Board believes that the excessive gib and out-of-limits side bearing clearances should have been detected by a designated car inspector in the car inspection system. The Safety Board is concerned that the excessive gib and out-of-limits side bearing clearances were not detected during the 12 or more interchange inspections and several predeparture inspections. Because detection of the excessive gib and out-of-limits side bearing clearances may have prevented the accident, the failure of car inspectors to do so is considered causal to the accident. The failure to detect the excessive gib clearance may have been in part because of the tendency of car inspectors to look for damaged or excessively worn parts, such as those later found on CNW 69883, rather than mismatched bolsters or sideframes. The testimony of the car inspector who last inspected WSOR 501003 prior to the accident also suggests, however, that car inspectors are not trained or instructed to look for excessive gib clearance. Further, testimony by the CSX supervisory personnel indicates that the car inspector would not have been expected to notice the excessive gib clearance.

The Safety Board notes the corrective action taken by CSX following the accident to improve inspections of side bearing and gib clearances. The Safety Board believes that the additional instructions and training regarding gib and side bearing clearance inspections should help to detect the type of excessive clearances that were evident in this accident. The Safety Board also believes that the Association of American Railroads should inform its members of the circumstances of the accident, emphasizing the need for car inspectors to check side bearing and gib clearances during inspections.

Northern Rail Car Corporation Shop Procedures

The many deficiencies noted during the postaccident inspection of the rebuilt WSOR series cars--including out-of-limits side bearing clearance, no side bearing clearance, loose side bearing top plates, a cracked side bearing top plate, mismatched truck sideframes, and excessive gib clearance --indicate that quality control procedures at the Northern Rail Car Corporation (NRCC) facility at the time the 36 cars were being rebuilt were inadequate. The Safety Board believes that procedures should have been in place at the NRCC to detect the deficiencies in the WSOR series cars. Therefore, the lack of adequate rebuild and quality control procedures at the NRCC is considered causal to the accident. The Safety Board notes, however, that following the accident, NRCC implemented new procedures including (1) the use of a quality control inspection sheet in conjunction with the repair of all cars to note, among other items, the measurement of gib and side bearing clearances, and (2) more frequent inspections by two supervisors as cars are being repaired. These improvements in shop procedures should help to eliminate the type of deficient repairs that were made during the rebuild project.

Association of American Railroads' Inspection of Freight Car Repair Shops

In February 1987, the AAR notified the NRCC freight car repair shop of deficiencies noted the month before during an inspection of the facility by an MID inspector; the AAR advised the shop to correct the deficiencies and requested to be informed when such action was taken. The AAR, however, did not followup to determine if the deficiencies had been corrected. The Safety Board believes that for the inspections to be effective, followup action is necessary to determine if deficiencies noted have been corrected.

Association of American Railroads' Inspection of Rebuilt Cars

AAR's procedures require that one or more rebuilt cars in a project be inspected by an MID inspector to determine if the car(s) meets all current safety standards and Interchange Rules. The Safety Board received conflicting testimony as to how many cars were available for inspection when the MID inspector visited the NRCC facility to inspect one of the cars from the project. The MID inspector stated that he inspected only one car because it was the only one available. The owner of the facility testified, however, that he believed five cars were available for inspection because of the numbering sequence of the cars. Regardless of the number of cars available at that time, only one car was inspected, and the MID inspector determined that it met all appropriate standards and rules and that all remaining cars should be rebuilt to the same specifications. The investigation revealed, however, that all remaining cars were not rebuilt to the same specifications. The Safety Board believes that one visit to the facility and the inspection of only one car is not sufficient to determine if all cars being rebuilt in the project meet the appropriate standards and rules. The AAR, therefore, should develop and implement procedures to provide for adequate followup inspections of cars during a rebuild project.

One of the cars in the rebuild project, WSOR 501017, as later noted by another MID inspector in Chicago, did not conform to AAR rules because it was equipped with threaded fittings in the air brake line and did not comply with FRA safety regulations because it was equipped with side ladders extending from the bottom to the top of the car. All 36 cars in the rebuild project were similarly equipped, and the AAR required the Wisconsin & Southern Railroad to correct these deficiencies. The Safety Board is concerned that these two areas of obvious noncompliance were not noted by the MID inspector who inspected WSOR 501032 at the NRCC facility and believes that the thoroughness of initial car inspections should be addressed in AAR's inspection procedures for rebuild projects.

Tank Car Performance

Two of the tank cars involved in the accident received hard hits in the top half of the tank head, yet no breaching of those tanks occurred. Several tank cars were fully engulfed in fire, yet there was no violent rupture from exposure to heat. All of these tank cars were equipped with head shields and thermal protection. Additionally, all nine tanks were equipped with shelf couplers, some of which broke during the derailment and resulted in strikes to tank car heads. The Safety Board believes that this accident

demonstrates the safety benefits of full tank car head shield and thermal protection even when the cars are equipped with vertical restraint (shelf) couplers.

On May 15, 1990, the Research and Special Programs Administration issued an Advance Notice of Proposed Rulemaking (ANPRM) "Specifications for Tank Car Tanks," [RSPA Docket No. HM-175A; Notice No. 90-8]. One of the issues addressed in the ANPRM relates to full head protection versus half head protection. The Safety Board has commented on this ANPRM citing the accident at Akron to illustrate the benefits of full head shield and thermal protection.

In its comments, the Safety Board stated that the accident data from the past 20 years clearly demonstrate the vulnerability of tank car heads to puncture during derailments even, at times, when equipped with shelf-type (vertical restraint) couplers. The effectiveness of head shields and thermal protection has been equally demonstrated in accidents involving tank cars that were so equipped. In addition, the Safety Board cited a recently completed study sponsored by the Railway Progress Institute and the AAR entitled "Analysis of Tank Cars Damaged in Accidents, 1965 through 1986," which concluded that the inclusion of shelf couplers and head shields reduced the probability of a head puncture on DOT specification 112 and 114 tank cars by 91 percent. The study also noted that 18 percent of the head punctures on DOT specification 112, 114, and 105 tank cars during the study period occurred in the upper half of the tank head. A second, similarly sponsored study entitled "Railroad Tank Car Safety Assessment" concluded that thermal protection, head shields, and shelf couplers are "clearly associated with the reduced spillage of hazardous materials in recent years."

The Safety Board's comments also pointed out that following its investigation of a collision and derailment at Helena, Montana, in 1989, the Board issued Safety Recommendation R-89-80 recommending that the DOT evaluate the degree of risk from the release of a hazardous material, identify the unacceptable levels of risk, and then modify existing regulations to achieve an acceptable level of safety for each product/tank car combination.

The Safety Board further stated that the execution of Safety Recommendation R-89-80 would take more than a few months to complete and that in the interim, because the need for head shield and thermal protection for the transportation of certain products in certain containers has already been well established, RSPA should move expeditiously to issue and implement final rules that would require full head shields and thermal protection for:

1. all DOT specification 105 tank cars with a capacity of 18,500 gallons or less and used to transport flammable gases, ethylene oxide, or other products that now require head shield

and thermal protection when shipped in 105 tank cars exceeding 18,500 gallons;[47] and

2. all tank cars transporting class A poisons, materials that are toxic by inhalation, and specialty products such as high strength acids, chlorine oxidizers, and other extremely reactive materials.

Initial Response to the Derailment by CSX Crewmembers and Supervisory Personnel

The crewmembers of D812-26 testified at the Safety Board's public hearing that although they had never been trained on the actions to take following an emergency situation, they recognized the importance of contacting emergency response personnel immediately following a derailment and providing information regarding hazardous materials involved. Their onscene actions immediately following the derailment, however, indicate otherwise. While the traincrew quickly called and informed the dispatcher of the derailment, prudently set up signals to warn approaching trains of the derailment, and used their documents to identify the northern- and southern-most cars involved in the derailment, there appeared to be no urgency in contacting the emergency response personnel onsite and providing the necessary information regarding the contents of the tank cars involved in the derailment. The front-end crew, apparently believing that either the dispatcher or the conductor would provide the necessary information to emergency response personnel, were leaving the accident site to get a soft drink at a nearby restaurant when they encountered a local police official, who then requested that the crewmembers meet with the fire chief. The conductor and flagman were preoccupied for more than an hour attempting to prevent onlookers from approaching too closely to the burning tank cars and never did seek emergency response personnel. While the crew should make every effort to protect onlookers from the dangers of derailed tank cars, the crew should have also recognized the need to contact emergency response personnel when it became evident that emergency response agencies were onscene. The Safety Board concludes that the traincrew, contrary to company instructions, did not contact as soon as possible emergency response personnel onsite to provide them with shipping papers and vital information about hazardous materials involved in the derailment. Although the Safety Board recognizes the confusion and unpredictable situations that may arise following a hazardous materials emergency, the actions of the crew of D812-26 were not indicative of a crew that had been instructed and trained thoroughly about actions to take following an emergency involving hazardous materials.

Even after the front-end crew came in contact with the fire chief, the crew did not convey accurate and complete information to the fire chief regarding the location of the other crewmembers and a second copy of the consist. After the brakeman and the fire chief returned to the accident site

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[47] All DOT specification 112 and 114 tank cars transporting flammable gases and anhydrous ammonia currently must have head shield and thermal protection.

and were unsuccessful in locating the lost profile, the brakeman contacted the conductor by radio to let the fire chief talk to the conductor about the cars involved in the derailment. However, neither the conductor nor the brakeman informed the fire chief that he was talking to the conductor or that the conductor and the flagman were at the rear of the train with a second copy of the profile (the fire chief believed that he was talking with someone in the rail yard). Had the fire chief been informed that he was talking to the conductor who was at the rear of the train with a second copy of the profile, the fire chief could have sent someone to that location to obtain the profile and much of the subsequent skepticism about the cars involved in the derailment could have been avoided. The traincrew's failure to communicate accurate and complete information to the fire chief again suggests a lack of thorough training on the actions to take immediately following an emergency involving hazardous materials.

The actions of the first arriving railroad supervisory personnel suggest that first line supervisors also had not been adequately instructed on the actions to take immediately following an emergency involving hazardous materials. After the CSX trainmaster arrived onscene and talked to the flagman by radio, he believed that fire department personnel had been provided with the necessary information regarding the derailed tank cars. He then returned to Akron Junction. He made no effort to contact the fire chief to determine if all necessary information had been provided or to verify the accuracy of the information. Although the Safety Board recognizes that supervisory personnel may have other responsibilities following a train derailment, the Board believes that supervisors must first verify that emergency response agencies have received accurate and timely information regarding any hazardous materials involved in the derailment.

The Safety Board has previously addressed the need for traincrews, as well as railroad supervisors, to be trained on the actions to be taken immediately following a train derailment involving hazardous materials, particularly the need to provide emergency response personnel with any documentation regarding hazardous materials that may be involved in the derailment. In its report of the derailment of a Seaboard Coast Line Railroad (now part of CSX Transportation) train at Colonial Heights, Virginia, on May 31, 1982,[48] the Safety Board stated:

> Throughout a hazardous materials emergency, and especially during the early minutes, it is essential that to the fullest extent possible, accurate and complete information be provided to emergency response personnel about the hazardous materials which present a threat to the safety of the public and the responding personnel. How quickly this information is provided to the appropriate personnel often determines the magnitude and duration of these incidents. The prompt transfer of accurate information is

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[48] National Transportation Safety Board. 1983. Derailment of Seaboard Coast Line Railroad train No. 120, at Colonial Heights, Virginia, on May 31, 1982. Railroad Accident Report NTSB/RAR-83/04. Washington, DC. 45 p.

one task which the Safety Board has observed repeatedly as being the main impediment to an efficient and coordinated response to a transportation accident involving hazardous materials.

As a result of its investigation of that accident, the Safety Board issued the following safety recommendations to the railroad:

R-83-48

Periodically instruct and test traincrews and supervisory personnel on the procedures for using train documents to identify all cars transporting hazardous materials and the information to be provided to assist emergency response personnel.

R-83-49

Require supervisory personnel arriving at the scene of an emergency to determine what information has been provided by traincrews to emergency response personnel, to verify the accuracy of the information provided, and to advise the onscene coordinator of any errors or omissions in the initial information given by the traincrews.

The recommendations were classified as "Closed--Acceptable Action" on May 24, 1983, after the railroad responded that the importance of notifying emergency response personnel of any hazardous materials entrained would be stressed in rules classes and timetable instructions.

As a result of its special investigation of the release of oleum during wreckage clearing operations after the derailment of a Seaboard System (now part of CSX) freight train in Clay, Kentucky, on February 5, 1984,[49] the Safety Board, on July 22, 1985, recommended that the railroad:

R-85-80

Modify its program of periodic training of train service employees to include instructions on the meaning and applications of operating rules applicable to an emergency involving hazardous materials.

The recommendation was classified as "Closed--Acceptable Response" on March 25, 1986, after the Seaboard System assured the Safety Board that all employees would receive instructions on those rules applicable to an emergency involving hazardous materials.

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[49] National Transportation Safety Board. 1985. Release of oleum during wreckage-clearing following derailment of Seaboard System Railroad train Extra 8294 North, Clay, Kentucky, February 5, 1984. Special Investigation Report NTSB/SIR-85/01. Washington, DC. 39 p.

As a result of its investigation of the derailment of a Baltimore and Ohio Railroad Company freight train near Miamisburg, Ohio, on July 8, 1986,[50] the Safety Board issued the following safety recommendation to CSX:

R-87-56

Reemphasize to all operating personnel the importance of directing their initial activities following a derailment to the cooperative support of local emergency response agencies.

On March 9, 1988, CSX informed the Safety Board of (1) the bulletins that had been issued addressing the "Prevent Accidental Chemical Exposure" program, (2) the revised hazardous materials training schedule, and (3) the procedures outlined in the CSX's Hazardous Materials Emergency Response Guide. Based on the information provided, the recommendation was classified as "Closed--Acceptable Action" on July 25, 1988.

The Safety Board believes that the accident in Akron illustrates that CSX personnel were still not provided adequate training on the actions to take immediately following an emergency situation despite the Safety Board's recommendations on this issue and CSX's assertions that this training was being accomplished. Although it appears that CSX management has made the necessary information available in the form of bulletins or guidelines, operating crews apparently are not understanding or being instructed sufficiently on the importance of this information. The Safety Board acknowledges CSX's efforts after the Akron accident (1) to provide division managers enhanced training on responding to rail transportation emergencies involving hazardous materials and (2) to review the feasibility of providing video tapes on hazardous materials rules and on emergency response for use in operating rules classes. The Safety Board believes, however, that specific training on responding to emergencies involving hazardous materials needs to be provided to traincrews and supervisory personnel in addition to what is covered in operating rules classes for traincrews. This training should include, at a minimum, the responsibility of crewmembers to identify themselves to emergency response personnel and to provide accurate information, including onboard documentation, of hazardous materials involved in the accident, and the responsibility of supervisory personnel to verify that emergency response personnel have all needed information and that it is accurate. The Safety Board also believes that the Association of American Railroads should notify its members and reemphasize the need to provide traincrews and supervisory personnel adequate training regarding the actions to take immediately following a train derailment.

The investigation revealed that none of the crewmembers had been tested on their knowledge of their responsibilities for emergencies involving hazardous materials. Further, a CSX trainmaster said that although he did

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[50] National Transportation Safety Board. 1987. Hazardous materials release following the derailment of Baltimore and Ohio Railroad Company train No. SLFR, Miamisburg, Ohio, July 8, 1986. Hazardous Materials Accident Report NTSB/HZM-87/01. Washington, DC. 90 p.

not evaluate the crewmembers after the accident, he took no exception to their actions. The Safety Board believes that evaluation is an integral part of employee training; it should be conducted in the classroom and in the operating environment to be certain employees understand their responsibilities and to provide a measure of the adequacy of the railroad's training program. The Safety Board believes that CSX should outline the means by which supervisors are to determine if their employees understand fully their responsibilities.

Notwithstanding the Safety Board's concern with the actions of the traincrew following the derailment, the Safety Board believes that the emergency response personnel should have made every effort to verify the location of crewmembers and train documents on both the front-end and rear-end of the train. The conductor, who is responsible for the train documents, typically rides at the rear of the train when a caboose is used at that location. The conductor testified, however, that for the more than 1 1/2 hours he was at the rear of the train, he never came in contact with any fire department personnel. The Safety Board acknowledges that it may be difficult to determine when initially arriving at the scene of an accident whether or not the train has a caboose. Nevertheless, emergency response personnel should routinely inquire about the location of all crewmembers and onboard train documents. The Safety Board believes that the International Association of Fire Chiefs, in notifying its members of the circumstances of the accident at Akron, would be the appropriate organization to emphasize this need to local emergency response personnel.

Because of the problems the fire department experienced in laying hoses and obtaining sufficient water supply, the delay in obtaining information about the tank cars involved in the derailment did not, in this instance, delay the fire department's attack on the fire. However, had there been no delay in providing the water supply, insufficient knowledge of the hazardous materials involved could have adversely affected the fire department's attack on the fire. It is vital that railroad personnel provide, and emergency response personnel obtain, as quickly as possible following the accident accurate information about the hazardous materials involved in the derailment. The Safety Board believes that the breakdown in communicating and locating vital information regarding the cars involved in the derailment may have resulted, in part, from the lack of jointly conducted emergency response drills and exercises between the city agencies and the railroad. The fire department and the B.F. Goodrich Chemical Company had engaged in emergency drills and preplanning for a disaster, which attests to the well organized manner in which the emergency situation at the chemical facility was handled.

The Safety Board has previously addressed the need for local emergency response agencies and railroads to conduct joint emergency preparedness exercises. The Safety Board's 1985 report[51] on rail yard safety reviewed

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[51] National Transportation Safety Board. 1985. Railroad yard safety: hazardous materials and emergency preparedness. Special Investigation Report NTSB/SIR-85/03. Washington, DC. 25 p.

the status of emergency preparedness for handling releases of hazardous materials in rail yards and concluded that much work remained to be accomplished. On April 30, 1985, the Safety Board issued the following safety recommendation to all railroads[52] that operate rail yards:

R-85-53

In coordination with communities adjacent to your railroad yards, develop and implement emergency planning and response procedures for handling releases of hazardous materials. These procedures should address, at a minimum, initial notification procedures, response actions for the safe handling of releases of the various types of hazardous materials transported, identification of key contact personnel, conduct of emergency drills and exercises, and identification of the resources to be provided and the actions to be taken by the railroad and the community.

The Seaboard System Railroad informed the Safety Board on July 21, 1985, that it was working with its "partner," the Chessie System Railroads, to ensure an appropriate and adequate response to a hazardous materials emergency in a railroad yard, including the coordination of its plans and procedures with local emergency responders. On February 8, 1988, the CSX informed the Safety Board that the Seaboard and the Chessie had merged their operations under the name of CSX Transportation, Inc., and this merger included the establishment of a single organization of hazardous materials specialists and adoption of the best features of both programs. The company informed the Safety Board that the CSX Prevent Accidental Chemical Exposure program for yards and terminals had been implemented and that this plan included the coordination of the emergency response plans and procedures with those in the community.

The Safety Board believes that although the railroad industry in general has recognized the need in the past few years to coordinate emergency response activity with local authorities and has taken steps toward that goal, further efforts by the railroads and the emergency response agencies are needed to fully accomplish this goal. This accident illustrates that CSX's prior efforts to coordinate emergency response plans and procedures with local response agencies had not been fully accomplished with all communities through which CSX trains operate. However, after the Akron accident, CSX, in cooperation with the fire departments and rescue agencies of Summit County and the City of Akron, conducted 6 days of comprehensive orientation, training, and field exercises on the handling of hazardous materials incidents in rail transportation. CSX indicated that it plans to conduct similar training programs at other locations in its system and was developing a computerized hazardous materials data program that could provide local emergency response agencies information about hazardous materials that

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[52] The Southern Railway System and the Chessie System Railroads were excluded as recipients of this recommendation because they already had established a corporate policy for meeting the objective of the recommendation.

are being transported through their communities. The Safety Board notes the actions taken by CSX after the Akron accident and urges the railroad to complete as soon as possible the training program, particularly to conduct emergency drills and exercises, with all communities through which CSX trains operate. Although Safety Recommendation R-85-53 to the Seaboard System Railroad (CSX) was being held in an "Open-Acceptable Action" status based on the railroad's efforts to address emergency preparedness, it is now being classified as "Closed--Acceptable Action/Superseded" as a result of the new recommendation being issued in conjunction with this report on the Akron accident.

Adequacy of Train Consist Information

There was no Federal or company requirement that after the train departed its initial terminal the train consist be updated as cars were either added or set off en route. The consist obtained by the Conrail safety supervisor in Cleveland and brought to the accident site did not reflect the makeup of the train at the time of the derailment. Even though the brakeman reviewed this document at the command post and identified which cars had been set off and added, the incident commander was not confident that only butane was involved in the derailment. As a result, he and the Conrail safety supervisor entered the accident area in an attempt to identify those cars involved in the derailment and exposed themselves needlessly to hazardous conditions. The company required that the conductor prepare a "wheel report" listing those cars that had been set off or added en route; however, at the time of the accident, the report did not identify the five cars that had been added at Warwick. The conductor was able to determine which cars derailed and, consequently, which hazardous materials were involved in the derailment by compiling information from several documents he carried and from information he learned from the front-end crew.

The onboard train documents are an early source of information for emergency response personnel for determining what hazardous materials may be involved in a derailment. The Safety Board believes, therefore, that the train consist should at all times accurately reflect the location and position of hazardous materials cars in the train. Without this up-to-date information, emergency response personnel are unable to plan appropriate actions. The Safety Board notes that CSX and the railroad industry are researching methods of providing aboard each train real-time documentation of train consists. The Union Pacific, for example, is experimenting with the use of onboard computers to generate real-time consist information. The Safety Board believes, however, that until adequate methods are developed, the FRA should revise the existing regulations to require that crews update train documents when cars are added or set off after the train has departed its initial terminal. Until the FRA has acted to revise the regulations, the CSX should require this of its operating crews.

Movement of Damaged Tank Cars

After the fire department was confident about the information regarding hazardous materials in the derailed tank cars, onscene activities were accomplished in a timely and professional manner. These activities included the response to the tank car fires, the response to the fire at the adjacent chemical facility, and the evacuation of residents. The fire department, and the city in general, however, depended on the expertise of the railroad for the removal of the wreckage from the initial derailment site. The operations chief considered it unsafe to unload the product from the tank cars at the accident site because of the continuing fire from tank car CITX 33875 and agreed with CSX's plan to rerail the tank cars and move them to Akron Junction yard where the cars would be more permanently secured for the movement to Canton--a location with facilities where the product could then be offloaded. The railroad, however, did not discuss alternatives with the city nor did the railroad advise the city of the possible risks associated with rerailing the tank cars. Only after the second event (when the tank car rolled off its trucks while being moved after the derailment) were alternative plans and the risks associated with each course of action discussed thoroughly with city officials.

The Safety Board recognizes the limited technical resources that may be available to local communities regarding wreckage clearing operations and understands the communities' reliance on the railroad to take the appropriate course of action. For this reason, it is necessary for the railroad to discuss with the local emergency response agencies the severity of known damage to tank cars carrying hazardous materials and the dangers posed to public safety, all possible courses of actions, and any associated risks. However, it is also important that the incident commander, as the person in charge of overall activity at the scene of an accident, play an active role and search out information about the severity of known tank car damage and dangers posed, possible solutions or alternatives, and risks involved. Further, the Safety Board is concerned that the presence of the FRA personnel, who may have been able to offer technical advice or guidance, was not made known to the incident commander until after the second event.

The decision by the railroad to rerail the tank cars at the initial derailment site concerns the Safety Board, aside from the fact that the risks associated with such a move were not discussed with local authorities. CSX mechanical personnel expressed concern that rerailing the tank cars for further movement was dangerous and not the preferred method. The Safety Board concludes that, given the assessment by CSX mechanical personnel and the severity of the damage to the tank car body bolsters and couplers, the railroad should not have rerailed the tank cars but, rather, should have waited until flatcars were available before moving the tanks from the derailment site.

The Safety Board has previously expressed concern about the need for written technical guidance to help emergency response personnel assess the severity of tank car damage and select the appropriate means to remove the wreckage. As a result of the Safety Board's investigation of a freight train derailment involving hazardous materials near Inwood, Indiana, on November 8, 1979,[53] a safety recommendation was issued asking the FRA to:

I-80-2

Develop guidelines for handling tank cars containing pressurized liquefied gases at accident sites based on research and tests of a representative sample of damaged tank cars.

In its initial response to this recommendation in May 1981, the FRA indicated that it agreed with the intent of the recommendation and would initiate a program to inspect damaged tank cars. In December 1981, the FRA indicated that it would coordinate the program with the AAR. Based on these responses, the safety recommendation has been classified as "Open--Acceptable Response." On July 3, 1990, the FRA provided an update on 21 open safety recommendations related to hazardous materials, including I-80-2. The FRA stated in that letter that the approach to Safety Recommendation I-80-2 outlined in 1981 "proved to be impracticable." The FRA, however, provided copies of work that has been done on this topic since the issuance of the recommendation, including AAR's publication "Tank Car Damage Assessment" and an FRA document used in its accident/incident investigation course on hazardous materials, portions of which address the assessment of the severity of tank car damage. The Safety Board has also been informed that the FRA, in conjunction with industry wreckage clearing experts, is currently developing technical guidelines to help wreckage clearing personnel assess the severity of tank car damage and select wreckage clearing actions based on damage assessments. The Safety Board has reviewed the AAR's publication and the FRA's investigation course material and believes that these documents and FRA's ongoing project with industry wreckage clearing experts address the concerns that prompted the Safety Board's recommendation. Pending completion of the FRA guidelines for wreckage clearing personnel, Safety Recommendation I-80-2 will be classified as "Open--Acceptable Alternate Response."

It is important to note that the AAR stated in the preface to its "Tank Car Damage Assessment" that these guidelines are to be used by individuals who have experience in assessing tank car damage and who are knowledgeable of tank car construction requirements and wreckage clearing operations. Emergency responders often do not have such technical experience and knowledge; however, they should be aware of these guidelines when securing the services of someone with this experience and knowledge, when assessing the seriousness of dangers posed as a result of tank car damages, and when evaluating alternative actions available to minimize those dangers. Further, FRA personnel responding to accidents should make their presence and purpose

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[53] National Transportation Safety Board. 1980. Tank car structural integrity after derailment. Special Investigation Report NTSB-SIR-80-1. Washington, DC. 37 p.

known to local emergency response personnel, inform local emergency response personnel of the guidance currently available for assessing tank car damage and wreckage clearing operations, and notify emergency response personnel of any imminently hazardous conditions that may exist.

Location of Chemical Plants and Other Hazardous Materials Facilities Near Railroad Tracks

Had the derailment caused more extensive damage to the B.F. Goodrich chemical facility, located adjacent to the railroad tracks, or caused damage to the pipelines transporting chemical products at the facility buildings, the accident could have been much more severe. The storage and production of hazardous materials in close proximity to mainline railroad tracks has long been a concern of the Safety Board.

On March 25, 1981, at Enos, Indiana, a railroad flatcar that had derailed struck three of four 1,000-gallon farm truck tanks loaded with anhydrous ammonia parked near the mainline tracks. Ammonia escaped from one of the breached tanks, mixed with fog, drifted across a divided highway 1/4 mile away, obscured motorists' vision, and led to multiple motor vehicle crashes. The distance from the tanks to the track ranged from about 19 to 40 feet. The flatcar traveled 65 feet from the track before coming to rest. On November 26, 1976, in Belt, Montana, one of several derailed railroad cars struck a 16,000-gallon gasoline storage tank. In the ensuing fire, the entire bulk storage plant burned; 2 persons were killed and 24 others were injured. The tank was located about 42 feet from the mainline track; several of the derailed cars traveled more than 100 feet from the track.

In a study of accidents investigated by the Board from 1976 to 1979, the Safety Board found that in 123 of 298 accidents (or about 41 percent), derailed cars traveled more than 50 feet (lateral distance) after leaving the track. In slightly more than 6 percent of the accidents, cars traveled more than 100 feet after leaving the track.

As a result of these accidents, the Safety Board issued the following Safety Recommendations I-82-1 through -4 to the AAR, I-82-5 to the National Association of Regulatory Utility Commissioners (NARUC), I-82-6 to the National Fire Protection Association (NFPA), and I-82-7 to the American National Standards Institute, Inc. (ANSI):

<u>I-82-1</u>

Reevaluate existing practices and standards influencing the placement of hazardous materials storage which may be vulnerable to damage by derailed railroad cars in train accidents.

I-82-2

Based on the results of a reevaluation of existing practices and standards, develop necessary changes in recommended practices to identify and protect vulnerable hazardous materials storage near mainline railroad tracks and disseminate these recommended practices to member companies for implementation.

I-82-3

In coordination with the National Association of Regulatory Utility Commissioners, identify actions States might take to require adequate protection of future hazardous materials storage near mainline railroad tracks against damage by derailed railroad cars in train accidents.

I-82-4

Coordinate development of recommended practices for identifying and protecting hazardous materials storage near mainline railroad tracks with the National Fire Protection Association and the American National Standards Institute, to assure consistency among related recommended safety practices.

I-82-5

Reevaluate State statutes and administrative orders to identify action States might take to improve protection of hazardous materials storage near railroad right-of-way against damage by derailed railroad cars in train accidents, and develop guidelines for State actions if needed.

I-82-6

Reevaluate National Fire Protection Association No. 30 "Flammable and Combustible Liquids Code" to assure adequate protection of hazardous materials storage located near mainline railroad tracks against derailed railroad cars in train accidents.

I-82-7

Reevaluate and amend as necessary American National Standards Institute Standard K61.1-1972, "Safety Requirements for the Storage and Handling of Anhydrous Ammonia," to provide adequate protection of hazardous materials containers located near mainline railroad tracks against derailed railroad cars in train accidents.

In regard to these safety recommendations, the Safety Board notes the efforts of the interindustry task force, established by the Chemical Manufacturers Association (CMA) and the AAR to address the safe transportation of hazardous materials by rail, and Circular OT-55

subsequently issued by the AAR to its members on this subject. The Safety Board has reviewed the circular and believes that it provides valuable guidance on separation distances of hazardous materials from mainline railroad tracks. The Safety Board believes, however, that the AAR should clarify and emphasize in its circular that hazardous materials storage and production facilities (including newly constructed and reconstructed facilities, tank cars, cargo tanks, and portable tanks) should be located no closer than 100 feet from mainline railroad tracks. The AAR in its recent letter of July 25, 1990, addressing Safety Recommendations I-82-1 through -4, and again referencing the work done by the interindustry task force, indicated that it intends to work with NARUC, NFPA, and ANSI to encourage these organizations to adopt recommendations on storage distances contained in Circular OT-55. The Safety Board is aware that the CMA has issued a notice to its members urging them to adopt recommendations on storage distances contained in the AAR's circular. In view of AAR's efforts, the Safety Board believes that the intent of Safety Recommendations I-82-1 and -2 has been met and, consequently, these recommendations have been classified as "Closed--Acceptable Action." Based on AAR's indication that it will work with the NARUC, the NFPA, and the ANSI to coordinate recommended practices and proposals with these agencies to assure that proposed separation distances are safe and consistent among related standards, Safety Recommendations I-82-3 and -4 will be classified as "Open--Acceptable Response" pending the outcome of this joint effort.

With respect to I-82-5, the Safety Board noted in 1983 the efforts made by NARUC to compile information on State regulations regarding protection of hazardous materials stored alongside railroad tracks. However, an analysis of this information was never conducted. In view of the increase in the transportation of hazardous materials by rail and the possible corresponding increase in the storage and production of these materials near railroad rights-of-way, the Safety Board believes that the NARUC should again survey the States to determine what regulations exist to provide protection of hazardous materials stored and produced at these locations and analyze the information compiled to determine if additional safeguards are needed. This information should then be shared with the AAR to aid in its ongoing efforts to coordinate separation distances to ensure that they are safe and consistent among related standards. Safety Recommendation I-82-5 is being classified as "Closed--Acceptable Action/Superseded" as a result of the new recommendation being issued in conjunction with this report.

The NFPA responded to Safety Recommendation I-82-6 on November 15, 1982, stating that modification of the existing guidelines was not necessary. The recommendation was, consequently, classified as "Closed--Unacceptable Action" on February 28, 1983. In view of a 1989 study of over 800 accidents conducted by AAR on lateral distances traveled by rail cars after leaving the track and in view of AAR's recent statement that it will work with NFPA to adopt the recommendations on storage distances, the Safety Board encourages the NFPA to revise, as necessary, all codes that address protection of hazardous materials storage and production facilities located near mainline railroad tracks in accordance with the AAR's study and Circular OT-55.

A response was never received from ANSI regarding I-82-7. Because of AAR's 1989 study and its efforts to coordinate separation distances, the Safety Board is issuing a new recommendation to ANSI to review its standards that address protection of hazardous materials storage and production facilities near mainline railroad tracks in accordance with the AAR's study and Circular OT-55. Consequently, Safety Recommendation I-82-7 has been classified as "Closed--Unacceptable Action/Superseded."

The Safety Board has previously expressed concern that land-use policies by communities do not take into account transportation-related safety issues, including the location of railroads or high pressure pipelines near populated areas. Because the issues do fall under the jurisdiction of local communities, the Safety Board, as a result of its investigation of a train derailment and subsequent pipeline rupture in San Bernardino, California,[54] issued safety recommendations to the National Association of Counties and the National League of Cities urging them to inform their members of the land-use guidance for enhancing public safety contained in the National Research Council's Special Report 219, "Pipeline and Public Safety," and encouraging them to develop and implement policies to protect public safety for lands adjacent to pipelines and railroads. As the Safety Board stated in its report of the San Bernardino accidents:

> The recommended actions in this report are specifically directed to public safety and land-use issues for pipelines, but the Safety Board believes, in principle, the discussion on land use would apply to railroads. Moreover, many of the considerations on land-use limitations for property adjacent to pipelines but not yet developed, also should be applied to land adjacent to railroads that has not been developed.

Similarly, the Safety Board believes that public safety policies on the uses of land adjacent to railroad tracks, including the location of hazardous materials storage and production facilities and the products being transported by rail, should be developed and implemented and urges the city of Akron to do so. Further, the Safety Board believes that the National League of Cities and the National Association of Counties should inform their members of the circumstances of the accident in Akron, and urge members, when developing or revising land-use policies on the location of hazardous materials storage and production facilities near railroad tracks, to require, as a minimum, setback distances consistent with the Association of American Railroads' (AAR) study on lateral distances traveled by derailed rail cars and AAR's Circular OT-55 "Recommended Railroad Operating Practices for Transportation of Hazardous Materials."

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[54] Railroad Accident Report NTSB/RAR-90/02.

CONCLUSIONS

Findings

1. The heavy rail burn marks on the B-end left sideframe of WSOR 501003 and the lack of similar marks on other cars indicate that WSOR 501003, the 13th car in the train behind the locomotives, was the first car to derail.

2. The excessive gib clearance on the B-end truck on WSOR 501003 and out-of-limits side bearing clearances existed before the accident and should have been detected by Northern Rail Car Corporation and railroad car inspectors.

3. Designated inspectors failed to detect excessive gib clearances on WSOR 501003 because these inspectors apparently have a tendency to look for damaged or excessively worn parts rather than mismatched bolsters or sideframes; this suggests that the training of the designated inspectors or the procedure for inspection of gib clearance was inadequate.

4. The marginal condition of the track in the area approaching the point of derailment and the existence of two turnouts in a curve caused increased lateral and vertical movement of car WSOR 501003 as it moved over the tracks.

5. The track was in marginal condition because track rehabilitation had not been performed for more than a year.

6. The quality and thoroughness of the Federal Railroad Administration's inspection of the track before the accident was inadequate.

7. The investigation was hampered in its effort to accurately determine the manner in which the train was being operated as it approached the accident site because the locomotive units were only equipped with three-event recorders.

8. Inadequate quality control procedures at the Northern Rail Car Corporation facility at the time the WSOR series cars were being rebuilt resulted in undetected deficiencies.

9. The Association of American Railroads (AAR) could not be certain that deficiencies noted during a routine AAR inspection of the Northern Rail Car Corporation facility in January 1987 had been corrected because no followup was conducted.

10. The Association of American Railroads' inspection of Northern Rail Car Corporation's rebuild project was deficient; further, inspection of a single car was insufficient to determine if all cars in the project were being rebuilt to the appropriate specifications.

11. The failure of the traincrew to immediately contact and provide emergency response personnel with shipping papers and vital information about hazardous materials involved in the derailment and the failure of first arriving railroad supervisory personnel to verify that all necessary information had been provided to emergency response personnel suggests that crews and first-line supervisors had not been instructed and trained properly on actions to take immediately following an emergency involving hazardous materials.

12. Emergency response personnel failed to verify the location of all crewmembers and train documents on both the front-end and rear-end of the train.

13. Inadequate communications between railroad and emergency response personnel about vital information regarding the cars and hazardous materials involved in the derailment may have resulted, in part, from the lack of jointly conducted emergency response drills and exercises between the city agencies and the railroad.

14. The onboard documents to which emergency response personnel initially refer may not accurately reflect the position of hazardous materials in the train because there is no requirement that these documents be updated as cars are set off or added en route.

15. The railroad and the incident commander did not adequately communicate about the possible alternatives to, and risks associated with, moving the damaged cars from the initial derailment site.

16. The railroad's decision to rerail the tank cars for further movement was not prudent in view of the assessment by CSX mechanical personnel and the severity of damage to the bolsters and couplers.

17. The location of the B.F. Goodrich facility adjacent to the mainline railroad tracks could have increased the severity of the accident because of the chemicals used within the facility.

Probable Cause

The National Transportation Safety Board determined that the probable cause of the derailment of train D812-26 in Akron, Ohio, on February 26, 1989, was the inadequate rebuild and quality control procedures of the Northern Rail Car Corporation car repair facility and the inadequate inspections of car WSOR 501003 by designated car inspectors that permitted the car to enter and continue in service with excessive gib clearance and out-of-limits side bearing clearance. Contributing to the accident was the marginal condition of the track as a result of Conrail's decision to delay rehabilitation of the track or not to place a slow order on the track.

RECOMMENDATIONS

As a result of its investigation of this accident, the National Transportation Safety Board made the following safety recommendations:

--to CSX Transportation:

Provide training, in addition to operating rules classes, to operating crews and supervisors on the actions they are to take immediately following an accident involving hazardous materials; this training should include, at a minimum, (1) the responsibility of crewmembers to identify themselves to emergency response personnel and to provide accurate information, including onboard documentation, of hazardous materials involved in the accident, (2) the responsibility of supervisory personnel to verify that emergency response personnel have all needed information and that it is accurate, and (3) the means by which supervisors are to determine if employees understand fully their responsibilities. (Class II, Priority Action) (R-90-28)

Complete, as soon as possible, drills and exercises for handling releases of hazardous materials with all communities through which CSX hazardous materials trains operate. (Class II, Priority Action) (R-90-29)

Require supervisory personnel to explain, before implementing wreckage clearing activities, to local emergency response agencies the alternative actions considered as well as the planned action and the risks associated with each. (Class II, Priority Action) (R-90-30)

Require traincrews to update the train consist to accurately reflect the position of hazardous materials as cars are added or set off en route. (Class II, Priority Action) (R-90-31)

--to the City of Akron:

Develop and implement public safety policies on the uses of lands adjacent to railroad tracks, including the location of hazardous materials storage and production facilities and the products being transported by rail. (Class II, Priority Action) (R-90-32)

--to the Association of American Railroads:

Notify members of the Association of American Railroads about the circumstances of the accident in Akron, Ohio, on February 26, 1989, emphasizing the need (1) for car inspectors to check side bearing and gib clearances during inspections, and (2) for traincrews and supervisory personnel to be provided adequate training regarding the actions to take immediately following a train derailment. (Class II, Priority Action) (R-90-33)

Require followup action on deficiencies noted during inspections of freight car repair facilities to determine if the deficiencies have been corrected. (Class II, Priority Action) (R-90-34)

Develop and implement procedures that provide for thorough and adequate initial and followup inspections of cars during a rebuild project. (Class II, Priority Action) (R-90-35)

Clarify and emphasize in Circular OT-55 that hazardous materials storage and production facilities (including newly constructed and reconstructed facilities, tank cars, cargo tanks, and portable tanks) should be located no closer than 100 feet from mainline railroad tracks. (Class II, Priority Action) (R-90-36)

--to the Federal Railroad Administration:

Evaluate the adequacy of track inspections being conducted on the Akron subdivision by Federal Railroad Administration inspectors and institute necessary changes to ensure thorough and consistent inspections. (Class II, Priority Action) (R-90-37)

Revise 49 CFR 174.26(b) to require the traincrew to maintain, at all times, a document reflecting the current position of hazardous materials cars in the train. (Class II, Priority Action) (R-90-38)

Require that Federal Railroad Administration personnel responding to a derailment involving hazardous materials (1) make their presence and purpose known to local emergency response personnel, (2) advise local authorities of guidance available for assessing tank car damage and wreckage clearing operations, and (3) notify emergency response personnel of any imminently hazardous conditions that may exist. (Class II, Priority Action) (R-90-39)

--to the International Association of Fire Chiefs:

Notify members of the International Association of Fire Chiefs about the circumstances of the accident in Akron, Ohio, on February 26, 1989, and urge them to emphasize to the appropriate emergency response personnel the need (1) to locate all crewmembers and train documents as a priority action when responding to a train accident, and (2) to search out information about the severity of known tank car damage and dangers posed, possible solutions or alternatives, and risks involved. (Class II, Priority Action) (R-90-40)

--to the National League of Cities and the National Association of Counties:

Inform your members of the circumstances of the CSX derailment in Akron, Ohio, on February 26, 1989, and urge them, when developing or revising land-use policies on the location of hazardous materials storage and production facilities near railroad tracks, to require, as a minimum, setback distances consistent with the Association of American Railroads' (AAR) 1989 study on lateral distances traveled by derailed rail cars and AAR's Circular No. OT-55, "Recommended Railroad Operating Practices for Transportation of Hazardous Materials." (Class II, Priority Action) (R-90-41)

--to the National Fire Protection Association:

Revise, as necessary, the Association's codes that address protection of hazardous materials storage and production facilities located near mainline railroad tracks, in accordance with the Association of American Railroads' (AAR) 1989 study on lateral distances traveled by derailed rail cars and AAR's Circular No. OT-55, "Recommended Railroad Operating Practices for Transportation of Hazardous Materials." (Class II, Priority Action) (R-90-42)

--to the American National Standards Institute, Inc.:

Revise, as necessary, the Institute's standards that address protection of hazardous materials storage and production facilities located near mainline railroad tracks, in accordance with the Association of American Railroads' (AAR) 1989 study on lateral distances traveled by derailed rail cars and AAR's Circular No. OT-55, "Recommended Railroad Operating Practices for Transportation of Hazardous Materials." (Class II, Priority Action) (R-90-43)

--to the National Association of Regulatory Utility Commissioners:

Survey State regulations to determine if additional safeguards are needed to provide protection of hazardous materials storage and production facilities near railroad rights-of-way and inform the Association of American Railroads (AAR) to aid the AAR in its efforts to coordinate separation distances between storage and production facilities and mainline railroad tracks. (Class II, Priority Action) (R-90-44)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

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Chairman

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Member

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Member

Adopted: September 25, 1990

APPENDIXES

APPENDIX A

INVESTIGATION AND HEARING

Investigation

The National Transportation Safety Board was notified of the accident about 8:30 p.m. eastern standard time on February 26, 1989. An investigative team was dispatched from headquarters in Washington, D.C., and from field offices in Chicago, Illinois; Denver, Colorado; and Ft. Worth, Texas. The team arrived at the accident scene on February 27, 1989. Investigative groups were established for operations, track, mechanical, hazardous materials, and emergency response factors.

Hearing

As part of its investigation of this accident, the Safety Board conducted a public hearing June 26-29, 1989, in Cleveland, Ohio. Parties to the investigation included the City of Akron, State of Ohio, CSX Transportation, Inc., Consolidated Rail Corporation, Federal Railroad Administration, Bureau of Explosives of the Association of American Railroads, B.F. Goodrich Chemical Company, and Northern Rail Car Corporation. Additionally, the Brotherhood of Maintenance of Way Employees and the Brotherhood of Railway Carmen were parties to the public hearing. Testimony was taken from 23 witnesses.

APPENDIX B

DEPARTMENT OF TRANSPORTATION
EMERGENCY RESPONSE GUIDE 22

Source: U.S. Department of Transportation, Research and Special Programs Administration, Office of Hazardous Materials Transportation. 1987. Emergency response guidebook: guidebook for initial response to hazardous materials incidents. DOT P 5800.4. Washington, DC. 76 guides plus supplemental pages.

GUIDE 22

POTENTIAL HAZARDS

FIRE OR EXPLOSION

Extremely flammable; may be ignited by heat, sparks or flames.
Vapors may travel to a source of ignition and flash back.
Container may explode in heat of fire.
Vapor explosion hazard indoors, outdoors or in sewers.

HEALTH HAZARDS

Vapors may cause dizziness or suffocation.
Contact will cause severe frostbite.
Fire may produce irritating or poisonous gases.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces before entering.
Self-contained breathing apparatus (SCBA) and structural firefighter's protective clothing will provide limited protection.
Isolate for 1/2 mile in all directions if tank car or truck is involved in fire.
CALL CHEMTREC AT 1-800-424-9300 AS SOON AS POSSIBLE, especially if there is no local hazardous materials team available.

FIRE

Let tank car, tank truck or storage tank burn unless leak can be stopped; with smaller tanks or cylinders, extinguish/isolate from other flammables.
Small Fires: Dry chemical, CO2 or Halon.
Large Fires: Water spray or fog.
Move container from fire area if you can do it without risk.
Cool containers that are exposed to flames with water from the side until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.

SPILL OR LEAK

Shut off ignition sources; no flares, smoking or flames in hazard area.
Do not touch spilled material; stop leak if you can do it without risk.
Use water spray to reduce vapors; isolate area until gas has dispersed.

FIRST AID

Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of frostbite, thaw frosted parts with water.
Keep victim quiet and maintain normal body temperature.

APPENDIX C

HAZARDOUS MATERIALS INFORMATION

Source: U.S. Department of Transportation, U.S. Coast Guard. 1984. CHRIS [chemical hazard response information system] hazardous chemical data. Commandant Instruction M16465.12A. Washington, DC. Vol. 2.

ACRYLONITRILE

ACN

Common Synonyms	Watery liquid	Colorless to light yellow	Irritating odor
Cyanoethylene Fumigrain Ventox Vinyl cyanide	Floats on water	Poisonous, flammable vapor is produced	

AVOID CONTACT WITH LIQUID AND VAPOR. KEEP PEOPLE AWAY.
Wear goggles, self-contained breathing apparatus and rubber overclothing (including gloves).
Shut off ignition sources and call fire department.
Stop discharge if possible.
Stay upwind and use water spray to knock down vapor.
Evacuate area in case of large discharge.
Isolate and remove discharged chemical.
Notify local health and pollution control agencies.

Fire

FLAMMABLE
POISONOUS GASES MAY BE PRODUCED IN FIRE
Flashback along vapor trail may occur
Vapor may explode if ignited in an enclosed area
Wear gloves, self-contained breathing apparatus and rubber overclothing (including gloves).
Remove from area if safe to do so or protected location.
Extinguish: Alcohol chemical, alcohol foam, or carbon dioxide.
Water may be ineffective on fire.
Cool exposed containers with water.

Exposure

VAPOR
POISONOUS IF INHALED.
Irritating to eyes
Move victim to fresh air.
If breathing has stopped, give artificial respiration.
If breathing is difficult, give oxygen.

LIQUID
POISONOUS IF SWALLOWED
Irritating to skin and eyes
Remove contaminated clothing and shoes.
Flush skin with plenty of water.
Flush eyes with plenty of water for 15 MINUTES. Have victim drink water or
Induce vomiting.
If poisoning occurs, call a physician.
DO NOTHING EXCEPT KEEP VICTIM WARM.

Water Pollution

HARMFUL TO AQUATIC LIFE IN VERY LOW CONCENTRATIONS.
Fouling to shoreline.
May be dangerous if it enters water intakes.
Notify local health and wildlife officials.
Notify other affected parties.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook)
Issue warning-poison, highly flammable
Restrict access
Disperse and flush

2. LABEL

2.1 **Category:** Flammable liquid, Poison
2.2 **Class:** 3 and 5

3. CHEMICAL DESIGNATIONS

3.1 **CG Compatibility Class:** Substituted ethyl
3.2 **Formula:** $CH_2=CHCN$
3.3 **IMO/UN Designation:** 3.1/1093
3.4 **DOT ID No.:** 1093
3.5 **CAS Registry No.:** 107-13-1

4. OBSERVABLE CHARACTERISTICS

4.1 **Physical State (as shipped):** Liquid
4.2 **Color:** Colorless
4.3 **Odor:** Mild, pungent, resembling that of peach seed kernels

5. HEALTH HAZARDS

5.1 **Personal Protective Equipment:** Air-supplied mask, industrial chemical type, with approved canister for acrylonitrile in low (less than 2%) concentrations, rubber or plastic gloves, cover goggles or face mask, rubber boots, slicker suit, safety helmet
5.2 **Symptoms Following Exposure:** Similar to those of hydrogen cyanide. Vapor inhalation may cause weakness, headache, sneezing, abdominal pain, and vomiting. Similar symptoms shown if large amounts of liquid are absorbed through the skin; lesser amounts cause stinging and sometimes blisters. Contact with eyes causes severe irritation. Ingestion produces nausea, vomiting and abdominal pain.
5.3 **Treatment of Exposure:** Skilled medical treatment is necessary; call physician for all cases of exposure. INHALATION: remove victim to fresh air. (Wear an oxygen or fresh-air-supplied mask when entering contaminated area.) INGESTION: induce vomiting by administering strong solution of salt water, but only if victim is conscious. SKIN: remove contaminated clothing and wash affected area thoroughly with soap and water. EYES: hold eyelids apart and wash with continuous gentle stream of water for at least 15 min. If victim is not breathing, give artificial respiration until physician arrives. If he is unconscious, crush an amyl nitrite ampule in a cloth and hold it under his nose for 15 seconds in every minute. Do not interrupt artificial respiration while doing this. Replace ampule when its strength is spent and continue treatment until condition improves or physician arrives.
5.4 **Threshold Limit Value:** 2 ppm
5.5 **Short Term Inhalation Limits:** 40 ppm for 30 minutes
5.6 **Toxicity by Ingestion:** Grade 3; LD_{50} 50 to 500 mg/kg (rat, guinea pig)
5.7 **Late Toxicity:** Data not available
5.8 **Vapor (Gas) Irritant Characteristics:** Vapor is moderately irritating such that personnel will not usually tolerate moderate or high vapor concentrations.
5.9 **Liquid or Solid Irritant Characteristics:** If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin. Large amounts may be absorbed through the skin and cause poisoning.
5.10 **Odor Threshold:** 21.4 ppm (Sense of smell fatigues rapidly)
5.11 **IDLH Value:** 4 ppm

6. FIRE HAZARDS

6.1 **Flash Point:** 30°F C.C., 31°F O.C.
6.2 **Flammable Limits in Air:** 3.05%-17.0%
6.3 **Fire Extinguishing Agents:** Dry chemical, alcohol foam, carbon dioxide
6.4 **Fire Extinguishing Agents Not to be Used:** Water or foam may cause frothing
6.5 **Special Hazards of Combustion Products:** When heated or burned, ACN may evolve toxic hydrogen cyanide gas and oxides of nitrogen
6.6 **Behavior in Fire:** Vapor is heavier than air and may travel a considerable distance to a source of ignition and flash back. May polymerize and explode
6.7 **Ignition Temperature:** 898°F
6.8 **Electrical Hazard:** Class I, Group D
6.9 **Burning Rate:** Data not available
6.10 **Adiabatic Flame Temperature:** Data not available

(Continued)

7. CHEMICAL REACTIVITY

7.1 **Reactivity With Water:** No reaction
7.2 **Reactivity with Common Materials:** Attacks copper and copper alloys, these metals should not be used. Penetrates leather, so contaminated leather shoes and gloves should be destroyed. Attacks aluminum in high concentrations
7.3 **Stability During Transport:** Stable
7.4 **Neutralizing Agents for Acids and Caustics:** Not pertinent
7.5 **Polymerization:** May occur spontaneously in absence of oxygen or on exposure to visible light or excessive heat, violently in the presence of alkali. Pure ACN is subject to self-polymerization with rapid pressure development. The commercial product is inhibited and not subject to this reaction

(Continued)

8. WATER POLLUTION

8.1 **Aquatic Toxicity:** 100 ppm/24 hr/all fish/100% killed/fresh water; 0.05-1 ppm/24 hr/bluegill/lethal/salt water
8.2 **Waterfowl Toxicity:** Not pertinent
8.3 **Biological Oxygen Demand (BOD):** 70%, 5 days
8.4 **Food Chain Concentration Potential:** None noted

9. SHIPPING INFORMATION

9.1 **Grades of Purity:** Technical 98-100%
9.2 **Storage Temperature:** Ambient
9.3 **Inert Atmosphere:** No requirement
9.4 **Venting:** Pressure-vacuum

10. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook)
A-P-Q-R-S-Z

11. HAZARD CLASSIFICATIONS

11.1 **Code of Federal Regulations:** Flammable liquid
11.2 **NAS Hazard Rating for Bulk Water Transportation:**

Category	Rating
Fire	3
Health	
Vapor Irritant	3
Liquid or Solid Irritant	1
Poisons	3
Water Pollution	
Human Toxicity	3
Aquatic Toxicity	4
Aesthetic Effect	3
Reactivity	
Other Chemicals	2
Water	3
Self Reaction	0

11.3 **NFPA Hazard Classification:**

Category	Classification
Health Hazard (Blue)	4
Flammability (Red)	3
Reactivity (Yellow)	2

12. PHYSICAL AND CHEMICAL PROPERTIES

12.1 **Physical State at 16°C and 1 atm:** Liquid
12.2 **Molecular Weight:** 53.06
12.3 **Boiling Point at 1 atm:** 171°F = 77.4°C = 350.6°K
12.4 **Freezing Point:** −118°F = −83.6°C = 189.6°K
12.6 **Critical Temperature:** 505°F = 263°C = 536°K
12.8 **Critical Pressure:** 660 psia = 45 atm = 4.6 MN/m²
12.7 **Specific Gravity:** 0.8075 at 20°C (liquid)
12.8 **Liquid Surface Tension:** Not pertinent
12.9 **Liquid Water Interfacial Tension:** Not pertinent
12.10 **Vapor (Gas) Specific Gravity:** 1.8
12.11 **Ratio of Specific Heats of Vapor (Gas):** 1.151
12.12 **Latent Heat of Vaporization:** 265 Btu/lb = 147 cal/g = 8.16 X 10⁵ J/kg
12.13 **Heat of Combustion:** −14,300 Btu/lb = −7930 cal/g = 332 X 10⁵ J/kg
12.14 **Heat of Decomposition:** Not pertinent
12.15 **Heat of Solution:** Not pertinent
12.16 **Heat of Polymerization:** Not pertinent
12.25 **Heat of Fusion:** Data not available
12.26 **Limiting Value:** Data not available
12.27 **Reid Vapor Pressure:** 3.5 psia

6. FIRE HAZARDS (Continued)

5.11 **Stoichiometric Air to Fuel Ratio:** Data not available
6.12 **Flame Temperature:** Data not available

7. CHEMICAL REACTIVITY (Continued)

7.6 **Inhibitor of Polymerization:** Methylhydroquinone (35-45 ppm)
7.7 **Molar Ratio (Reactant to Product):** Data not available
7.8 **Reactivity Group:** 15

ACN ACRYLONITRILE

12.17 SATURATED LIQUID DENSITY		12.18 LIQUID HEAT CAPACITY		12.19 LIQUID THERMAL CONDUCTIVITY		12.20 LIQUID VISCOSITY	
Temperature (degrees F)	Pounds per cubic foot	Temperature (degrees F)	British thermal unit per pound-F (estimate)	Temperature (degrees F)	British thermal unit-inch per hour-square foot-F	Temperature (degrees F)	Centipoise
0	52.800	28	.499	75	1.150		N
5	52.620	30	.499	80	1.143		O
10	52.450	32	.499	85	1.136		T
15	52.280	34	.499	90	1.128		
20	52.100	36	.499	95	1.121		P
25	51.930	38	.499	100	1.114		E
30	51.760	40	.499	105	1.107		R
35	51.580	42	.499	110	1.099		T
40	51.410	44	.499	115	1.092		I
45	51.240	46	.499	120	1.085		N
50	51.060	48	.499	125	1.078		E
55	50.890	50	.499	130	1.070		N
60	50.720	52	.499	135	1.063		T
65	50.540	54	.499	140	1.056		
70	50.370	56	.499	145	1.049		
75	50.190	58	.499	150	1.041		
80	50.020	60	.499	155	1.034		
85	49.850	62	.499	160	1.027		
90	49.670	64	.499				
95	49.500	66	.499				
100	49.330	68	.499				
105	49.150	70	.499				
110	48.980	72	.499				
115	48.810	74	.499				
120	48.630	76	.499				
125	48.460	78	.499				

12.21 SOLUBILITY IN WATER		12.22 SATURATED VAPOR PRESSURE		12.23 SATURATED VAPOR DENSITY		12.24 IDEAL GAS HEAT CAPACITY	
Temperature (degrees F)	Pounds per 100 pounds of water	Temperature (degrees F)	Pounds per square inch	Temperature (degrees F)	Pounds per cubic foot	Temperature (degrees F)	British thermal unit per pound-F
70.02	8.000	0	.193	0	.00208	0	.261
		10	.277	10	.00291	25	.270
		20	.390	20	.00402	50	.280
		30	.540	30	.00545	75	.289
		40	.735	40	.00727	100	.297
		50	.987	50	.00957	125	.306
		60	1.306	60	.01242	150	.314
		70	1.707	70	.01593	175	.323
		80	2.205	80	.02019	200	.331
		90	2.815	90	.02532	225	.338
		100	3.558	100	.03142	250	.346
		110	4.452	110	.03863	275	.354
		120	5.520	120	.04707	300	.361
		130	6.786	130	.05688	325	.368
		140	8.274	140	.06820	350	.375
		150	10.010	150	.08117	375	.382
		160	12.030	160	.09594	400	.389
		170	14.350	170	.11260	425	.395
		180	17.010	180	.13150	450	.401
		190	20.040	190	.15250	475	.408
		200	23.480	200	.17590	500	.414
		210	27.360	210	.20190	525	.420
		220	31.710	220	.23060	550	.425
		230	36.570	230	.26210	575	.431
						600	.437

AMMONIA, anhydrous

AMA

Common Synonyms
Liquid Ammonia

Liquefied compressed gas. Colorless. Ammonia odor.

Floats and boils on water. Poisonous, visible vapor cloud is produced.

[illegible]
Wear goggles, self-contained breathing apparatus, and rubber overclothing [illegible]
Stop ammonia gas [illegible]
Stay upwind and use water spray to knock down vapor.
Call fire department.
Isolate and remove damaged material.
Notify local health and other [illegible] agencies.

Fire

Combustible.
Wear goggles, self-contained breathing apparatus, and rubber over [illegible] gloves.
Stop flow of gas if liquid is possible.
[illegible] and protect men effecting shutoff with water [illegible]

Exposure

[illegible]

VAPOR
POISONOUS IF INHALED.
Irritating to eyes, nose and throat.
[illegible] with plenty of water.
[illegible] given artificial respiration.
[illegible]

LIQUID
Will burn skin and eyes.
Harmful if swallowed.
Will cause frostbite.
[illegible]
[illegible] with plenty of water.
[illegible] have victim drink water [illegible]

Water Pollution

HARMFUL TO AQUATIC LIFE IN VERY LOW CONCENTRATIONS.
May be dangerous if it enters water intakes.
[illegible]

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook)
Issue warning-poison.
Restrict access.
Evacuate area.
Disperse and flush.

2. LABEL

2.1 Category: Nonflammable gas
2.2 Class: 2

3. CHEMICAL DESIGNATIONS

3.1 CG Compatibility Class. Ammonia
3.2 Formula: NH_3
3.3 IMO/UN Designation: 2.0/1005
3.4 DOT ID No.: 1005
3.5 CAS Registry No.: 7664-41-7

4. OBSERVABLE CHARACTERISTICS

4.1 Physical State (as shipped): Compressed liquefied gas
4.2 Color: Colorless
4.3 Odor: Pungent, extremely pungent

5. HEALTH HAZARDS

5.1 Personal Protective Equipment: Gas-tight chemical goggles, self-contained breathing apparatus, rubber boots, rubber gloves, emergency shower and eye bath.
5.2 Symptoms Following Exposure. 700 ppm causes eye irritation, and permanent injury may result if prompt remedial measures are not taken. 5000 ppm can cause immediate death from spasm, inflammation, or edema of the larynx. Contact of the liquid with skin freezes the tissue and then produces a caustic burn.
5.3 Treatment of Exposure: INHALATION: move victim to fresh air and give artificial respiration if necessary. Oxygen may be useful. Observe for laryngeal spasm and perform tracheostomy if indicated. SKIN OR EYES: flood immediately with running water for 15 min. Treat subsequently as thermal burn.
5.4 Threshold Limit Value: 25 ppm
5.5 Short Term Inhalation Limits: 50 ppm for 5 min
5.6 Toxicity by Ingestion: Not pertinent
5.7 Lethal Toxicity: Not pertinent
5.8 Vapor (Gas) Irritant Characteristics: Vapors cause severe eye or throat irritation and may cause eye or lung injury. vapors cannot be tolerated even at low concentrations.
5.9 Liquid or Solid Irritant Characteristics: Causes smarting of the skin and first-degree burns on short exposure; may cause secondary burns on long exposure.
5.10 Odor Threshold. 46.8 ppm
5.11 IDLH Value. 500 ppm

6. FIRE HAZARDS

6.1 Flash Point: Not flammable under conditions likely to be encountered.
6.2 Flammable Limits in Air: 15.50% - 27.00%
6.3 Fire Extinguishing Agents: Stop flow of gas or liquid. Let fire burn.
6.4 Fire Extinguishing Agents Not to be Used: None
6.5 Special Hazards of Combustion Products: Not pertinent
6.6 Behavior in Fire: Not pertinent
6.7 Ignition Temperature: 1204°F
6.8 Electrical Hazard: Class I, Group D
6.9 Burning Rate: 1 mm/min.
6.10 Adiabatic Flame Temperature: Data not available
6.11 Stoichiometric Air to Fuel Ratio: 6.050 (Est.)
6.12 Flame Temperature: Data not available

7. CHEMICAL REACTIVITY

7.1 Reactivity With Water: Dissolves with mild heat effect
7.2 Reactivity with Common Materials: Corrosive to copper and galvanized surfaces
7.3 Stability During Transport: Stable
7.4 Neutralizing Agents for Acids and Caustics: Dilute with water
7.5 Polymerization: Not pertinent
7.6 Inhibitor of Polymerization: Not pertinent
7.7 Molar Ratio (Reactant to Product): Data not available
7.8 Reactivity Group: Data not available

8. WATER POLLUTION

8.1 Aquatic Toxicity:
2.0 - 2.5 ppm/1-4 days/goldfish and yellow perch/LC
60 - 80 ppm/3 days/crayfish/LC_{100}
6.2 ppm/96 hr/fathead minnow/TL_m
8.2 Waterfowl Toxicity: 120 ppm
8.3 Biological Oxygen Demand (BOD): Not pertinent
8.4 Food Chain Concentration Potential: None

9. SHIPPING INFORMATION

9.1 Grades of Purity: Commercial, industrial, refrigeration, electronic, and metallurgical grades all have purity greater than 99.5%.
9.2 Storage Temperature: Ambient for pressurized ammonia, low temperature for ammonia at atmospheric pressure.
9.3 Inert Atmosphere: No requirement
9.4 Venting: Safety relief 250 psi for ammonia under pressure. Pressure-vacuum for ammonia at atmospheric pressure.

10. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook)
A-B-C-K-L-M-N-O

11. HAZARD CLASSIFICATIONS

11.1 Code of Federal Regulations: Nonflammable gas
11.2 NAS Hazard Rating for Bulk Water Transportation:

Category	Rating
Fire	1
Health	
Vapor Irritant	4
Liquid or Solid Irritant	2
Poisons	2
Water Pollution	
Human Toxicity	2
Aquatic Toxicity	2
Aesthetic Effect	2
Reactivity	
Other Chemicals	2
Water	3
Self Reaction	2

11.3 NFPA Hazard Classification:

Category	Classification	
Health Hazard (Blue)	2	3
Flammability (Red)	1	1
Reactivity (Yellow)	0	0

12. PHYSICAL AND CHEMICAL PROPERTIES

12.1 Physical State at 16°C and 1 atm: Gas
12.2 Molecular Weight: 17.03
12.3 Boiling Point at 1 atm: −28.1°F = −33.4°C = 239.8°K
12.4 Freezing Point: −108°F = −77.7°C = 265.5°K
12.5 Critical Temperature: 271°F = 133°C = 406°K
12.6 Critical Pressure: 1636 psia = 111.3 atm = 11.27 MN/m²
12.7 Specific Gravity: 0.682 at -33.4°C (liquid)
12.8 Liquid Surface Tension: Not pertinent
12.9 Liquid Water Interfacial Tension: Not pertinent
12.10 Vapor (Gas) Specific Gravity: 0.6
12.11 Ratio of Specific Heats of Vapor (Gas): 1.3 at 20°C
12.12 Latent Heat of Vaporization: 589 Btu/lb = 327 cal/g = 13.7 X 10³ J/kg
12.13 Heat of Combustion: −7992 Btu/lb = −4440 cal/g = −185.9 X 10³ J/kg
12.14 Heat of Decomposition: Not pertinent
12.15 Heat of Solution: −232 Btu/lb = −129 cal/g = −5.40 X 10³ J/kg
12.16 Heat of Polymerization: Not pertinent
12.25 Heat of Fusion: Data not available
12.26 Limiting Value: Data not available
12.27 Reid Vapor Pressure: 211.9 psia

NOTES

AMA — AMMONIA, anhydrous

12.17 SATURATED LIQUID DENSITY		12.18 LIQUID HEAT CAPACITY		12.19 LIQUID THERMAL CONDUCTIVITY		12.20 LIQUID VISCOSITY	
Temperature (degrees F)	Pounds per cubic foot	Temperature (degrees F)	British thermal unit per pound-F	Temperature (degrees F)	British thermal unit-inch per hour-square foot-F	Temperature (degrees F)	Centipoise
—105	42.070	—75	1.041		N		N
—100	42.200	—70	1.043		O		O
—95	42.310	—65	1.046		T		T
—90	42.410	—60	1.049				
—85	42.500	—55	1.052		P		P
—80	42.570	—50	1.054		E		E
—75	42.630	—45	1.057		R		R
—70	42.680	—40	1.060		T		T
—65	42.720	—35	1.063		I		I
—60	42.740	—30	1.066		N		N
—55	42.750				E		E
—50	42.750				N		N
—45	42.730				T		T
—40	42.700						
—35	42.660						
—30	42.600						

12.21 SOLUBILITY IN WATER		12.22 SATURATED VAPOR PRESSURE		12.23 SATURATED VAPOR DENSITY		12.24 IDEAL GAS HEAT CAPACITY	
Temperature (degrees F)	Pounds per 100 pounds of water	Temperature (degrees F)	Pounds per square inch	Temperature (degrees F)	Pounds per cubic foot	Temperature (degrees F)	British thermal unit per pound-F
	M	—40	10.470	—40	.03957	0	.487
	I	—35	12.080	—35	.04514	25	.494
	S	—30	13.900	—30	.05132	50	.501
	C	—25	15.940	—25	.05816	75	.508
	I	—20	18.220	—20	.06573	100	.515
	B	—15	20.760	—15	.07406	125	.523
	L	—10	23.590	—10	.08322	150	.530
	E	—5	26.730	—5	.09326	175	.538
		0	30.210	0	.10420	200	.546
		5	34.040	5	.11620	225	.554
		10	38.270	10	.12930	250	.562
		15	42.920	15	.14340	275	.571
		20	48.020	20	.15880	300	.579
		25	53.600	25	.17540	325	.588
		30	59.690	30	.19340	350	.597
		35	66.330	35	.21270	375	.606
		40	73.549	40	.23350	400	.615
		45	81.400	45	.25590	425	.625
		50	89.900	50	.27980	450	.635
		55	99.099	55	.30550	475	.645
		60	109.000	60	.33290	500	.655
		65	119.700	65	.36210	525	.665
		70	131.299	70	.39320	550	.675
		75	143.699	75	.42630	575	.686
		80	157.000	80	.46150	600	.697
		85	171.199	85	.49870		

BUTADIENE

BDI

Common Synonyms
Divinyl
Vinylethylene
1, 3-Butadiene
Bethylene
Bivinyl

Liquefied compressed gas — Colorless — Gasoline-like odor

Floats and boils on water. Flammable visible vapor cloud is produced

Avoid contact with liquid and gas. Keep people away.
Wear goggles, self-contained breathing apparatus, and rubber overclothing (including gloves).
Stop discharge, if possible.
Shut off ignition sources and call fire department.
Evacuate area in case of large discharge.
Stay upwind and use water spray to knock down vapor.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire

FLAMMABLE.
Containers may explode in fire.
Flashback along vapor trail may occur.
Vapor may explode if ignited in an enclosed area.
Wear goggles, self-contained breathing apparatus, and rubber overclothing (including gloves).
Stop flow of gas if possible.
Cool exposed containers and protect man affecting shut-off with water.
Let fire burn.

Exposure

CALL FOR MEDICAL AID.

VAPOR
Irritating to eyes, nose and throat.
Move to fresh air.

LIQUID
Irritating to skin and eyes.
Remove contaminated clothing and shoes.
Flush affected areas with plenty of water.
FLUSH EYES. Hold eyelids open and flush with plenty of water.

Water Pollution

Not harmful to aquatic life.
May be dangerous if it enters water intakes.
Notify operators of nearby water intakes.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook)
Issue warning-high flammability.
Evacuate area.

2. LABEL

2.1 **Category:** Flammable liquid
2.2 **Class:** 2

3. CHEMICAL DESIGNATIONS

3.1 **CG Compatibility Class:** Olefin
3.2 **Formula:** $CH_2 = CHCH = CH_2$
3.2 **IMO/UN Designation:** 2.0/1010
3.4 **DOT ID No.:** 1010
3.5 **CAS Registry No.:** 106-99-0

4. OBSERVABLE CHARACTERISTICS

4.1 **Physical State (as shipped):** Gas
4.2 **Color:** Colorless
4.3 **Odor:** Mildly aromatic

5. HEALTH HAZARDS

5.1 **Personal Protective Equipment:** Chemical-type safety goggles, rescue harness and life line for those entering a tank or enclosed storage space, hose mask with hose inlet in a vapor-free atmosphere, self-contained breathing apparatus; rubber suit
5.2 **Symptoms Following Exposure:** Slight anesthetic effect at high concentrations; causes "frostbite" from skin contact, slight irritation to eyes and nose at high concentrations
5.3 **Treatment of Exposure:** Remove from exposure immediately. Call a physician. INHALATION: If breathing is irregular or stopped, start resuscitation, administer oxygen. SKIN CONTACT: remove contaminated clothing and wash affected skin area. EYE CONTACT: irrigate with water for 15 min
5.4 **Threshold Limit Value:** 1,000 ppm
5.5 **Short Term Inhalation Limits:** Data not available
5.6 **Toxicity by Ingestion:** Data not available
5.7 **Late Toxicity:** None
5.8 **Vapor (Gas) Irritant Characteristics:** Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary
5.9 **Liquid or Solid Irritant Characteristics:** Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin because of frostbite
5.10 **Odor Threshold:** 4 mg/m³
5.11 **IDLH Value:** 20 000 ppm

6. FIRE HAZARDS

6.1 **Flash Point:** 105°F (est.)
6.2 **Flammable Limits in Air:** 2.0%-11.5%
6.3 **Fire Extinguishing Agents:** Stop flow of gas
6.4 **Fire Extinguishing Agents Not to be Used:** Not pertinent
6.5 **Special Hazards of Combustion Products:** Not pertinent
6.6 **Behavior in Fire:** Vapors heavier than air and may travel a considerable distance to a source of ignition and flashback. Containers may explode in a fire due to polymerization.
6.7 **Ignition Temperature:** 788°F
6.8 **Electrical Hazard:** Class 1, Group B
6.9 **Burning Rate:** 8.0 mm/min.
6.10 **Adiabatic Flame Temperature:** Data not available

(Continued)

7. CHEMICAL REACTIVITY

7.1 **Reactivity With Water:** Not flammable
7.2 **Reactivity with Common Materials:** No reaction
7.3 **Stability During Transport:** Explosive decomposition when contaminated with peroxides formed by reaction with air
7.4 **Neutralizing Agents for Acids and Caustics:** Not pertinent
7.5 **Polymerization:** Stable when inhibitors present
7.6 **Inhibitor of Polymerization:** tert-Butylcatechol (0.01-0.02%)
7.7 **Molar Ratio (Reactant to Product):** Data not available
7.8 **Reactivity Group:** 30

8. WATER POLLUTION

8.1 **Aquatic Toxicity:** Not pertinent
8.2 **Waterfowl Toxicity:** Not pertinent
8.3 **Biological Oxygen Demand (BOD):** Not pertinent
8.4 **Food Chain Concentration Potential:** Not pertinent

9. SHIPPING INFORMATION

9.1 **Grades of Purity:** Research grade: 99.86 mole% Special purity: 99.5 mole% Rubber grade: Commercial.
9.2 **Storage Temperature:** Ambient
9.3 **Inert Atmosphere:** No requirement
9.4 **Venting:** Safety relief

10. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook)

A-B-C-D-E-F-G-Z

11. HAZARD CLASSIFICATIONS

11.1 **Code of Federal Regulations:** Flammable gas
11.2 **NAS Hazard Rating for Bulk Water**

Transportation: Category	Rating
Fire	4
Health	
Vapor Irritant	1
Liquid or Solid Irritant	1
Poisons	1
Water Pollution	
Human Toxicity	1
Aquatic Toxicity	0
Aesthetic Effect	1
Reactivity	
Other Chemicals	1
Water	2
Self Reaction	0

11.3 **NFPA Hazard Classification:**

Category	Classification
Health Hazard (Blue)	2
Flammability (Red)	4
Reactivity (Yellow)	2

12. PHYSICAL AND CHEMICAL PROPERTIES

12.1 **Physical State at 15°C and 1 atm:** Gas
12.2 **Molecular Weight:** Data not available
12.3 **Boiling Point at 1 atm:** 24.1°F = —4.4°C = 268.8°K
12.4 **Freezing Point:** —164°F = —108.9°C = 164.3°K
12.5 **Critical Temperature:** 306°F = 152°C = 425°K
12.6 **Critical Pressure:** 628 psia = 42.7 atm = 4.32 MN/m²
12.7 **Specific Gravity:** 0.821 at 20°C (liquid)
12.8 **Liquid Surface Tension:** 13.4 dynes/cm = 0.0134 N/m at 22°C
12.9 **Liquid Water Interfacial Tension:** (est.) 67 dynes/cm = 0.067 N/m at 22°C
12.10 **Vapor (Gas) Specific Gravity:** 1.9 at 20°C
12.11 **Ratio of Specific Heats of Vapor (Gas):** 1.1
12.12 **Latent Heat of Vaporization:** 180 Btu/lb = 100 cal/g = 4.18 X 10⁵ J/kg
12.13 **Heat of Combustion:** —18,005 Btu/lb = —10,560 cal/g = —442.13 X 10⁵ J/kg
12.14 **Heat of Decomposition:** Not pertinent
12.15 **Heat of Solution:** Not pertinent
12.16 **Heat of Polymerization:** —548 Btu/lb = —305 cal/g = —12.8 X 10⁵ J/kg
12.17 **Heat of Fusion:** 35.28 cal/g
12.18 **Limiting Value:** Data not available
12.19 **Reid Vapor Pressure:** 81 psia

6. FIRE HAZARDS (Continued)

6.11 **Stoichiometric Air to Fuel Ratio:** 13.96 (est.)
6.12 **Flame Temperature:** Data not available

BDI BUTADIENE

12.17 SATURATED LIQUID DENSITY		12.18 LIQUID HEAT CAPACITY		12.19 LIQUID THERMAL CONDUCTIVITY		12.20 LIQUID VISCOSITY	
Temperature (degrees F)	Pounds per cubic foot	Temperature (degrees F)	British thermal unit per pound-F	Temperature (degrees F)	British thermal unit-inch per hour-square foot-F	Temperature (degrees F)	Centipoise
—110	45.610	—110	.453		N	—110	.437
—100	45.220	—100	.459		O	—100	.404
—90	44.840	—90	.465		T	—90	.375
—80	44.460	—80	.471			—80	.349
—70	44.080	—70	.478		P	—70	.326
—60	43.700	—60	.484		E	—60	.306
—50	43.320	—50	.490		R	—50	.288
—40	42.940	—40	.496		T	—40	.272
—30	42.550	—30	.502		I	—30	.258
—20	42.170	—20	.508		N	—20	.245
—10	41.790	—10	.514		E	—10	.233
0	41.410	0	.520		N	0	.222
10	41.030	10	.526		T	10	.212
20	40.650	20	.533			20	.203

12.21 SOLUBILITY IN WATER		12.22 SATURATED VAPOR PRESSURE		12.23 SATURATED VAPOR DENSITY		12.24 IDEAL GAS HEAT CAPACITY	
Temperature (degrees F)	Pounds per 100 pounds of water	Temperature (degrees F)	Pounds per square inch	Temperature (degrees F)	Pounds per cubic foot	Temperature (degrees F)	British thermal unit per pound-F
	I	—55	1.795	—55	.02235	0	.307
	N	—50	2.109	—50	.02594	25	.322
	S	—45	2.466	—45	.02997	50	.336
	O	—40	2.872	—40	.03448	75	.350
	L	—35	3.331	—35	.03952	100	.364
	U	—30	3.847	—30	.04512	125	.377
	B	—25	4.426	—25	.05131	150	.390
	L	—20	5.074	—20	.05815	175	.403
	E	—15	5.796	—15	.06568	200	.416
		—10	6.598	—10	.07394	225	.428
		—5	7.487	—5	.08297	250	.440
		0	8.468	0	.09283	275	.451
		5	9.549	5	.10350	300	.463
		10	10.740	10	.11520	325	.474
		15	12.040	15	.12780	350	.485
		20	13.460	20	.14140	375	.495
		25	15.010	25	.15600	400	.505
		30	16.690	30	.17180	425	.515
		35	18.520	35	.16870	450	.525
		40	20.500	40	.20680	475	.535
		45	22.650	45	.22610	500	.544
		50	24.960	50	.24670	525	.553
		55	27.440	55	.26870	550	.562
		60	30.120	60	.29200	575	.571
		65	32.980	65	.31680	600	.579
		70	36.050	70	.34300		

BUTANE

BUT

Common Synonyms	Liquefied compressed gas	Colorless	Gasoline-like odor
n-Butane	Floats and boils on water. Flammable, visible vapor cloud is formed.		

Stop discharge if possible, keep people away
Shut off ignition sources and call fire department
Stay upwind and use water spray to knock down vapor
Avoid contact with liquid and vapor
Notify local health and pollution control agencies

Fire

FLAMMABLE.
Flashback along vapor trail may occur.
Vapor may explode if ignited in an enclosed area.
Stop flow of gas if possible
Cool exposed containers and protect men attacking shut-off with water
Let fire burn

Exposure

SEE FIRE MEDICAL AID

VAPOR
If inhaled, will cause dizziness or difficult breathing
Not irritating to eyes, nose or throat
Move to fresh air
If breathing has stopped, give artificial respiration
If breathing is difficult, give oxygen

LIQUID
Will cause frostbite.
Flush affected areas with plenty of water
SEE FIRE MEDICAL AID FOR AFFECTED AREAS

Water Pollution

Not harmful to aquatic life.
May be dangerous if it enters water intakes
Take precautions to protect water intakes

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook)

Issue warning-high flammability
Restrict access
Evacuate area

2. LABEL

2.1 Category: Flammable gas
2.3 Class: 2

3. CHEMICAL DESIGNATIONS

3.1 CG Compatibility Class: Paraffin
3.2 Formula: $n\text{-}C_4H_{10}$
3.3 IMO/UN Designation: 2.0/1011
3.4 DOT ID No.: 1011
3.5 CAS Registry No.: 106-97-8

4. OBSERVABLE CHARACTERISTICS

4.1 Physical State (as shipped): Compressed gas
4.3 Color: Colorless
4.3 Odor: Like gasoline

5. HEALTH HAZARDS

5.1 Personal Protective Equipment: Self-contained breathing apparatus and safety goggles
5.2 Symptoms Following Exposure: High exposure produces drowsiness but no other evidence of systemic effect
5.3 Treatment of Exposure: ORAL AND ASPIRATION: No treatment required. INHALATION: Guard against self-injury if stuporous, confused, or anesthetized. Apply artificial respiration if not breathing. Avoid administration of epinephrine or other sympathomimetic amines. Prevent aspirations of vomitus by proper positioning of the head. Give symptomatic and supportive treatment
5.4 Threshold Limit Value: 800 ppm
5.5 Short Term Inhalation Limits: Data not available
5.6 Toxicity by Ingestion: Not pertinent
5.7 Late Toxicity: None
5.8 Vapor (Gas) Irritant Characteristics: None
5.9 Liquid or Solid Irritant Characteristics: No appreciable hazard. Practically harmless to the skin because it is very volatile and evaporates quickly from the skin. Some frostbite possible
5.10 Odor Threshold: 8.15 ppm
5.11 IDLH Value: Data not available

6. FIRE HAZARDS

6.1 Flash Point: —100°F (est.)
6.2 Flammable Limits in Air: 1.6%-8.4%
6.3 Fire Extinguishing Agents: Stop flow of gas
6.4 Fire Extinguishing Agents Not to be Used: Not pertinent
6.5 Special Hazards of Combustion Products: Not pertinent
6.6 Behavior in Fire: Not pertinent
6.7 Ignition Temperature: 550°F
6.8 Electrical Hazard: Class 1, Group D
6.9 Burning Rate: 7.6 mm/min
6.10 Adiabatic Flame Temperature: 2435. (Est.)
6.11 Stoichiometric Air to Fuel Ratio: 15.35 (Est.)
6.12 Flame Temperature: Data not available

7. CHEMICAL REACTIVITY

7.1 Reactivity With Water: No reaction
7.2 Reactivity with Common Materials: No reaction
7.3 Stability During Transport: Stable
7.4 Neutralizing Agents for Acids and Caustics: Not pertinent
7.5 Polymerization: Not pertinent
7.6 Inhibitor of Polymerization: Not pertinent
7.7 Molar Ratio (Reactant to Product): Data not available
7.8 Reactivity Group: 31

8. WATER POLLUTION

8.1 Aquatic Toxicity: None
8.2 Waterfowl Toxicity: None
8.3 Biological Oxygen Demand (BOD): None
8.4 Food Chain Concentration Potential: None

9. SHIPPING INFORMATION

9.1 Grades of Purity: Research 99.95%, Pure 99.4%, Technical 97.6%
9.2 Storage Temperature: Ambient
9.3 Inert Atmosphere: No requirement
9.4 Venting: Safety relief

10. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook)

A-B-C-D-E-F-G

11. HAZARD CLASSIFICATIONS

11.1 Code of Federal Regulations: Flammable gas
11.2 NAS Hazard Rating for Bulk Water

Transportation: Category	Rating
Fire	4
Health	
Vapor Irritant	0
Liquid or Solid Irritant	0
Poisons	0
Water Pollution	
Human Toxicity	0
Aquatic Toxicity	0
Aesthetic Effect	0
Reactivity	
Other Chemicals	0
Water	0
Self Reaction	0

11.3 NFPA Hazard Classification:

Category	Classification
Health Hazard (Blue)	1
Flammability (Red)	4
Reactivity (Yellow)	0

12. PHYSICAL AND CHEMICAL PROPERTIES

12.1 Physical State at 15°C and 1 atm: Gas
12.2 Molecular Weight: 58.12
12.2 Boiling Point at 1 atm: 31.1°F = —0.48°C = 272.72°K
12.4 Freezing Point: —216°F = —138°C = 135°K
12.5 Critical Temperature: 306°F = 152°C = 425°K
12.6 Critical Pressure: 550.8 psia = 37.47 atm = 3.796 MN/m²
12.7 Specific Gravity: 0.60 at 0°C (liquid)
12.8 Liquid Surface Tension: 14.7 dynes/cm = .0147 N/m at 0°C
12.8 Liquid Water Interfacial Tension: (est.) 65 dynes/cm = 0.065 N/m at 22°C
12.10 Vapor (Gas) Specific Gravity: 2.0 at 20°C
12.11 Ratio of Specific Heats of Vapor (Gas): 1.092
12.12 Latent Heat of Vaporization: 170 Btu/lb = 92 cal/g = 3.8 X 10⁵ J/kg
12.13 Heat of Combustion: —19,512 Btu/lb = —10,840 cal/g = —453.85 X 10³ J/kg
12.14 Heat of Decomposition: Not pertinent
12.15 Heat of Solution: Not pertinent
12.16 Heat of Polymerization: Not pertinent
12.26 Heat of Fusion: 19.16 cal/g
12.26 Limiting Value: Data not available
12.27 Reid Vapor Pressure: 52.4 psia

NOTES

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12.17 SATURATED LIQUID DENSITY	
Temperature (degrees F)	Pounds per cubic foot
—110	41.940
—100	41.630
—90	41.320
—80	41.000
—70	40.690
—60	40.380
—50	40.070
—40	39.750
—30	39.440
—20	39.130
—10	38.820
0	38.510
10	38.190
20	37.880
30	37.570

12.18 LIQUID HEAT CAPACITY	
Temperature (degrees F)	British thermal unit per pound-F
—30	.535
—20	.542
—10	.550
0	.557
10	.564
20	.571
30	.578

12.19 LIQUID THERMAL CONDUCTIVITY	
Temperature (degrees F)	British thermal unit-inch per hour-square foot-F
	N
	O
	T
	P
	E
	R
	T
	I
	N
	E
	N
	T

12.20 LIQUID VISCOSITY	
Temperature (degrees F)	Centipoise
—110	.535
—105	.511
—100	.489
—95	.468
—90	.449
—85	.431
—80	.414
—75	.398
—70	.383
—65	.369
—60	.356
—55	.344
—50	.332
—45	.321
—40	.311
—35	.301
—30	.292
—25	.283
—20	.275
—15	.267
—10	.260
—5	.253
0	.246
5	.239
10	.233
15	.227

12.21 SOLUBILITY IN WATER	
Temperature (degrees F)	Pounds per 100 pounds of water
	I
	N
	S
	O
	L
	U
	B
	L
	E

12.22 SATURATED VAPOR PRESSURE	
Temperature (degrees F)	Pounds per square inch
—90	.420
—80	.624
—70	.905
—60	1.283
—50	1.784
—40	2.435
—30	3.269
—20	4.320
—10	5.629
0	7.237
10	9.192
20	11.540
30	14.340
40	17.640
50	21.510
60	25.990
70	31.160
80	37.080

12.23 SATURATED VAPOR DENSITY	
Temperature (degrees F)	Pounds per cubic foot
—90	.00616
—80	.00890
—70	.01257
—60	.01739
—50	.02358
—40	.03142
—30	.04119
—20	.05320
—10	.06778
0	.08525
10	.10600
20	.13030
30	.15860
40	.19120
50	.22850
60	.27080
70	.31850
80	.37200

12.24 IDEAL GAS HEAT CAPACITY	
Temperature (degrees F)	British thermal unit per pound-F
0	.380
25	.377
50	.392
75	.408
100	.424
125	.439
150	.454
175	.468
200	.483
225	.497
250	.511
275	.525
300	.539
325	.552
350	.585
375	.578
400	.591
425	.603
450	.615
475	.628
500	.639
525	.651
550	.663
575	.674
600	.685

STYRENE

STY

Common Synonyme
Styrol
Vinylbenzene
Phenylethylene
Styrolene

Watery liquid — Colorless to light yellow — Sweet pleasant odor

Floats on water. Flammable, irritating vapor is produced

Avoid contact with liquid and vapor, keep people away
Wear chemical protective suit with self-contained breathing apparatus
Stop discharge if possible
Call fire department
Isolate and remove discharged material
Notify local health and pollution control agencies

Fire

FLAMMABLE
CONTAINERS MAY EXPLODE IN FIRE
Flashback along vapor trail may occur
Vapor may explode if ignited in an enclosed area
Wear chemical protective suit with self-contained breathing apparatus
Combatting from safe distance or protected location
Extinguish with dry chemical, foam, or carbon dioxide
Water may be ineffective on fire
Cool exposed containers with water

Exposure

CALL FOR MEDICAL AID

VAPOR
Irritating to eyes, nose and throat
If inhaled, will cause dizziness or loss of consciousness
Move victim to fresh air
If breathing has stopped, give artificial respiration
If breathing is difficult, give oxygen

LIQUID
Will burn skin and eyes
Harmful if swallowed
Remove contaminated clothing and shoes
Flush affected areas with plenty of water
IF IN EYES, hold eyelids open and flush with plenty of water
IF SWALLOWED and victim is CONSCIOUS, have victim drink water (two glasses)
DO NOT INDUCE VOMITING

Water Pollution

HARMFUL TO AQUATIC LIFE IN VERY LOW CONCENTRATIONS
Fouling to shoreline
May be dangerous if it enters water intakes

Notify local health and wildlife officials
Notify downstream health water intakes

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook)
Issue warning-air contaminant
Mechanical containment
Should be removed
Chemical and physical treatment

2. LABEL

2.1 Category: Flammable liquid
2.2 Class: 3

3. CHEMICAL DESIGNATIONS

2.1 CG Compatibility Class: Olefin
3.2 Formula: $C_6H_5CH=CH_2$
2.3 IMO/UN Designation: 3.3/2055
2.4 DOT ID No.: 2055
3.5 CAS Registry No.: 100-42-5

4. OBSERVABLE CHARACTERISTICS

4.1 Physical State (as shipped): Liquid
4.2 Color: Colorless
4.3 Odor: Sweet at low concentrations, characteristic pungent, sharp, disagreeable

5. HEALTH HAZARDS

5.1 Personal Protective Equipment: Air-supplied mask or approved canister; rubber or plastic gloves, boots, goggles or face shield
5.2 Symptoms Following Exposure: Moderate irritation of eyes and skin. High vapor concentrations cause dizziness, drunkenness, and anesthesia
5.3 Treatment of Exposure: INHALATION: remove to fresh air; keep warm and quiet; use artificial respiration if needed. INGESTION: do NOT induce vomiting, call physician, no known antidote. SKIN OR EYE CONTACT: flush with plenty of water; for eyes get medical attention.
5.4 Threshold Limit Value: 50 ppm
5.5 Short Term Inhalation Limits: 100 ppm for 30 min
5.6 Toxicity by Ingestion: Grade 2, LD_{50} = 0.5 to 5 g/kg
5.7 Late Toxicity: Data not available
5.8 Vapor (Gas) Irritant Characteristics: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary.
5.9 Liquid or Solid Irritant Characteristics: Causes smarting of the skin and first-degree burns on short exposure; may cause secondary burns on long exposure
5.10 Odor Threshold: 0.148 ppm
5.11 IDLH Value: 5,000 ppm

6. FIRE HAZARDS

6.1 Flash Point: 93°F O.C., 88°F C.C.
6.2 Flammable Limits in Air: 1.1%-6.1%
6.3 Fire Extinguishing Agents: Water fog, foam, carbon dioxide, or dry chemical
6.4 Fire Extinguishing Agents Not to be Used: Water may be ineffective
6.5 Special Hazards of Combustion Products: Not pertinent
6.6 Behavior in Fire: Vapor is heavier than air and may travel considerable distance to a source of ignition and flash back. At elevated temperatures such as in fire conditions, polymerization may take place which may lead to container explosion
6.7 Ignition Temperature: 914°F
6.8 Electrical Hazard: Class I, Group D
6.9 Burning Rate: 5.2 mm/min
6.10 Adiabatic Flame Temperature: Data not available

(Continued)

7. CHEMICAL REACTIVITY

7.1 Reactivity With Water: No reaction
7.2 Reactivity with Common Materials: No reaction
7.3 Stability During Transport: Stable
7.4 Neutralizing Agents for Acids and Caustics: Not pertinent
7.5 Polymerization: May occur if heated above 150°F. Can cause rupture of container. Metal salts, peroxides, and strong acids may also cause polymerization
7.6 Inhibitor of Polymerization: Tertiary-butylcatechol, 10-15 ppm
7.7 Molar Ratio (Reactant to Product): Data not available
7.8 Reactivity Group: 30

8. WATER POLLUTION

8.1 Aquatic Toxicity: 22 ppm/96 hr/bluegill/TL_m/fresh water
8.2 Waterfowl Toxicity: Data not available
8.3 Biological Oxygen Demand (BOD): 16% (theor.), 412 days
8.4 Food Chain Concentration Potential: None

9. SHIPPING INFORMATION

9.1 Grades of Purity: 99.5+%
9.2 Storage Temperature: Ambient
9.3 Inert Atmosphere: No requirement
9.4 Venting: Open (flame arrester)

10. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook)
A-T-U-Z

11. HAZARD CLASSIFICATIONS

11.1 Code of Federal Regulations: Flammable liquid
11.2 NAS Hazard Rating for Bulk Water

Category	Rating
Transportation:	
Fire	3
Health	
Vapor Irritant	2
Liquid or Solid Irritant	2
Poisons	2
Water Pollution	
Human Toxicity	1
Aquatic Toxicity	3
Aesthetic Effect	2
Reactivity	
Other Chemicals	2
Water	0
Self Reaction	3

11.2 NFPA Hazard Classification:

Category	Classification
Health Hazard (Blue)	2
Flammability (Red)	3
Reactivity (Yellow)	2

12. PHYSICAL AND CHEMICAL PROPERTIES

12.1 Physical State at 15°C and 1 atm: Liquid
12.2 Molecular Weight: 104.15
12.3 Boiling Point at 1 atm: 293.4°F = 145.2°C = 418.4°K
12.4 Freezing Point: −23.1°F = −30.6°C = 242.6°K
12.5 Critical Temperature: 703°F = 373°C = 646°K
12.6 Critical Pressure: 580 psia = 39.46 atm = 4.00 MN/m²
12.7 Specific Gravity: 0.906 at 20°C (liquid)
12.8 Liquid Surface Tension: 32.14 dynes/cm = 0.03214 N/m at 19°C
12.9 Liquid Water Interfacial Tension: 35.46 dynes/cm = 0.03546 N/m at 19°C
12.10 Vapor (Gas) Specific Gravity: Not pertinent
12.11 Ratio of Specific Heats of Vapor (Gas): 1.074
12.12 Latent Heat of Vaporization: 156 Btu/lb = 86.8 cal/g = 3.63 X 10⁵ J/kg
12.13 Heat of Combustion: Not pertinent
12.14 Heat of Decomposition: Not pertinent
12.15 Heat of Solution: Not pertinent
12.16 Heat of Polymerization: −277 Btu/lb = −154 cal/g = −6.45 X 10⁵ J/kg
12.25 Heat of Fusion: Data not available
12.26 Limiting Value: Data not available
12.27 Reid Vapor Pressure: 0.27 psia

6. FIRE HAZARDS (Continued)

6.11 Stoichiometric Air to Fuel Ratio: Data not available
6.12 Flame Temperature: Data not available

STY	STYRENE

12.17 SATURATED LIQUID DENSITY		12.18 LIQUID HEAT CAPACITY		12.19 LIQUID THERMAL CONDUCTIVITY		12.20 LIQUID VISCOSITY	
Temperature (degrees F)	Pounds per cubic foot	Temperature (degrees F)	British thermal unit per pound-F	Temperature (degrees F)	British thermal unit-inch per hour-square foot-F	Temperature (degrees F)	Centipoise
40	57.430	0	.389	15	1.087	40	.950
50	57.120	5	.391	20	1.080	50	.872
60	56.800	10	.393	25	1.074	60	.803
70	56.490	15	.395	30	1.067	70	.742
80	56.180	20	.397	35	1.060	80	.688
90	55.870	25	.399	40	1.054	90	.639
100	55.560	30	.401	45	1.047	100	.595
110	55.240	35	.403	50	1.040	110	.556
120	54.930	40	.405	55	1.033	120	.521
130	54.620	45	.407	60	1.027	130	.488
140	54.310	50	.409	65	1.020	140	.459
150	54.000	55	.411	70	1.013	150	.433
160	53.680	60	.413	75	1.006	160	.408
170	53.370	65	.415	80	1.000	170	.386
180	53.060	70	.417	85	.993	180	.366
190	52.750	75	.419	90	.986	190	.347
200	52.430	80	.421	95	.980	200	.330
210	52.120	85	.423	100	.973	210	.314
		90	.424	105	.966		
		95	.426	110	.959		
		100	.428	115	.953		
		105	.430	120	.946		
		110	.432				
		115	.434				
		120	.436				

12.21 SOLUBILITY IN WATER		12.22 SATURATED VAPOR PRESSURE		12.23 SATURATED VAPOR DENSITY		12.24 IDEAL GAS HEAT CAPACITY	
Temperature (degrees F)	Pounds per 100 pounds of water	Temperature (degrees F)	Pounds per square inch	Temperature (degrees F)	Pounds per cubic foot	Temperature (degrees F)	British thermal unit per pound-F
68.02	.300	40	.034	40	.00066	0	.239
		50	.049	50	.00094	25	.253
		60	.070	60	.00131	50	.266
		70	.099	70	.00181	75	.279
		80	.137	80	.00247	100	.292
		90	.188	90	.00332	125	.304
		100	.254	100	.00440	150	.317
		110	.339	110	.00577	175	.329
		120	.447	120	.00748	200	.340
		130	.583	130	.00959	225	.352
		140	.753	140	.01218	250	.363
		150	.963	150	.01532	275	.374
		160	1.221	160	.01911	300	.385
		170	1.534	170	.02364	325	.396
		180	1.912	180	.02900	350	.406
		190	2.365	190	.03533	375	.416
		200	2.905	200	.04272	400	.426
		210	3.542	210	.05132	425	.435
		220	4.292	220	.06126	450	.445
		230	5.167	230	.07269	475	.454
		240	6.183	240	.08575	500	.462
		250	7.358	250	.10060	525	.471
		260	8.709	260	.11740	550	.479
		270	10.250	270	.13630	575	.487
		280	12.010	280	.15760	600	.495
		290	14.010	290	.18130		

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